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Existing Urban River Rehabilitation Schemes

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1 Introduction

1.1 Urban River Rehabilitation and the URBEM project

Cultural requirements and natural properties meet directly at riversides in urban areas. Sustainable development needs knowledge of the interrelations between urban conditions and the state of waters as well as instruments and techniques for their management. This is especially true for the industrial nations of Europe where much of the population live in cities and towns. Impacts on waters of sewage discharge, the high dynamics of storm water runoff, limited groundwater recharge, fragmentation, canalisation, culverting and others cause serious effects on aquatic organisms and the whole water ecosystems. In return they lead to manifold influences on urban life like e.g. decrease of water supply, risk to public health due to chemical and bacteriological water pollution, threats by flooding or loss of quality of urban open spaces by reduced aesthetic value.

Aesthetic value also represents an important factor for the economic prosperity and social life in the riverine districts. To maintain the potentials for urban development in this areas degradation of urban waters should be avoided. Therefore, urban pressures on waters have to be minimised. Beside the ongoing reduction of the sewage water discharge the development of urban waters need to be seen as a comprehensive task (Schanze 2002a,b). In contrast to historical river modifications for various purposes of utilisation, current and future generations require an enhancement of the sustainability of European urban waters.

This altered perspective is especially exemplified by the European Water Framework Directive (WFD). As a main instrument of the European Water Policy it has been introduced to avoid further deterioration of and, if possible, to improve all kind of waters. For surface waters it determines a "good surface water status" (Article 4/1/ii). As far as morphological limitations cannot be removed the WFD gives cities an opportunity to define "heavily modified water bodies". In this case as a less stringent standard, "good ecological potential", needs to be reached (Article 4/1/iii). However, cities should not feel disengaged from improving the qualities of their waters. At least "good surface water chemical status" will be required for heavily modified and artificial water bodies, too. It can be expected that most advanced techniques utilized in some of the existing installations become "best practicable technology" in water resource management. They will be required to reach "good ecological potential" in heavily modified water bodies.

Additionally urban waters are especially sensitive to climatic extremes such as droughts and heavy precipitation, which can be exacerbated by the urban environment. Therefore the rehabilitation of degraded urban waters including the creation of wetlands in future will be even more important in buffering adverse climatic impacts.

When planning the enhancement of urban rivers the social and economic requirements of the adjacent urban areas are of major importance. Thus, safety and health features and the environmental quality of life in proximity of rivers have to be considered beside the ecological and chemical state of water bodies. They refer to aesthetic and amenity values, accessibility and environmental-conscious utilisation. Therefore, design, planning and implementation require an adequate participation of all stakeholders to ensure public acceptance of river enhancement.

A comprehensive understanding of urban river rehabilitation and design is the objective of the research project "Urban River Basin Enhancement Methods" (URBEM; cf. Bettess et al., in prep.) funded by the European Commission under the 5th Framework Programme, Key Action 4 "City of tomorrow and cultural heritage". It includes an investigation on the current state of urban river enhancement as well as the development of new tools, innovative techniques and improved procedures to enhance water courses in urban areas. These tools should provide planning assistance for the differing, multi-functional uses of urban water courses and their adjacent communities across Europe. They are aimed at assisting decision makers in sustainable management of urban rivers. Altogether, the URBEM research project builds up a comprehensive framework to facilitate urban water course rehabilitation and enhancement in Europe. Based on this it includes training and briefing modules, to the public, professionals and environment authorities.

1.2 Investigation of existing urban river rehabilitation schemes

A study on the current state of urban river rehabilitation in Europe has been carried out. This survey of completed rehabilitation schemes aims at maximising the benefit that can be derived from any existing practical experience. Moreover, it is considered as a baseline for the further development of new tools, techniques and procedures. The collection and examination of information from these schemes provide an overview of the state of the art. Good techniques and measures as well as good planning practices currently used are presented. Good techniques and measures are of great interest to practitioners throughout Europe and indeed are the necessary basis for their further improvement. Good planning practice with successful implementation is required to meet the public participation requirements set by WFD Article 14. Altogether results show how selected communities planned and implemented projects that reached a desirable status of urban waters as part of a sustainable urban development solution for the cities of tomorrow.

Due to the variety of ecological and societal characteristics in the European Union a wide range of different approaches of urban river rehabilitation can be expected. This diversity will increase through the accession of the new Member States of the European Union. Thus, the investigation not only needs to cover a comprehensive understanding of urban river rehabilitation but also needs to reflect the spectrum of local schemes within identical criteria. The scope of the investigation is set by the following topics in the context of urban river rehabilitation:

- Planning and implementation process
- Rehabilitation techniques
- Ecological, social and economic impacts
- Aesthetic evaluation
- Social appraisal and community involvement
- Performance control and indicators of success

The *planning and implementation process* is dedicated to the way rehabilitation schemes are selected and how decisions have been made. It includes legal conditions, political willingness to act and the funding process. Under *rehabilitation techniques* all physical activities are summed, which mainly influence the river channel, its instream hydromorphological conditions as well as water quality. They also include measures with importance for public health and safety. These measures cause various impacts on the natural and societal systems. The approach thus considers the three dimensions of sustainability comprising *ecological, social and economic impacts*. In urban areas aesthetics play a significant role in river rehabilitation. The *evaluation of the aesthetic state*, therefore, has to be addressed as an additional aspect. *Social Appraisal and public involvement* addresses the identification, information and active involvement of stakeholders as well as reach-out programs for advocacy and stewardship to initiate and maintain projects. Finally, *performance control and indicators of success* provides information for quantification and monitoring of project outcomes. Those not only include criteria for successful rehabilitation but also criteria for the entire rehabilitation process and its final result and will be specifically addressed in a subsequent part of URBEM. To deal with the presented requirements a specific research approach was developed and carried out for selected rehabilitation schemes (see below).

1.3 Baselines of urban water rehabilitation

Waters in all their shapes continue to play a major role in human development all over the world. Surface waters are being used and shaped according to human needs, aesthetic ideals and technical options. This is of special relevance in large urban areas like towns and cities. The character of urban rivers and their basins differentiate fundamentally from those in rural and natural areas (cf. e.g. FISRWG 1998, 3-22). A long history of extensive human interventions in rivers has shaped urban riverscapes. Today they are characterised by anthropogenic impairments and spatial constraints in an artificial environment. A multitude of overlapping uses in urban areas interferes with river ecology and can lead to negative conditions for urban development (see above). In addition uses have competing needs and spatial requirements. Such conflicts for instance do exist between drinking water supply and wastewater discharge, flood protection and ecological functions, historic preservation and waterfront development as well as between recreation areas and river navigation locks. Societal demands can thus form effective obstacles for river rehabilitation enhancement activities demanding a high level of effort from all planning participants.

One can identify a number of typical pressures on urban waters that result from anthropogenic activities. Due to their relevance for all components of waters, they are categorised according the WFD in hydrological, morphological, physico-chemical and biological aspects. The latter is understood as depending on the combination of the other ones. The following outline is based on FISRWG (1998) and Baer & Pringle (2000) and refers also to de Waal et al. (1995), Harper et al. (1998) and Vannote et al. (1980):

<u>Hydrological component</u>

- Increased runoff from sealed or impervious urban surfaces
- Higher discharge dynamic, increased in magnitude and frequency of occurrence
- Increased flow velocities in the water courses
- Increased risk of erosion
- Decreased dry weather base flow feeding streams
- Impounded river sections for different purposes (e.g. weirs)

<u>Morphological component</u>

- Denaturalised stream alignments and gradients (e.g. spatial constraints from adjacent housing, industry and urban infrastructure, river canalisation)
- Bed and bank stabilisations

- Culverted sections under infrastructure, building and portions of towns and cities
- Installation of urban infrastructure along or underneath the water course (sewer pipes, power supply lines, gas and water pipelines, roads etc.)
- Unbalanced sediment regime due to unnatural streambed erosion by increased flow velocity, decreased natural sediment input and increased entry of unnatural sediments and material from urban surfaces and tempory impact of construction sites
- General loss of sediment transfer causing management problems

Physico-chemical component (water quality)

- Immission of various substances (e.g. nutrients, heavy metals, salt, organic compounds) from urban point (e.g. sewer overflows or direct waste water discharges) and non-point sources (urban surfaces drainage)
- Disturbed conditions of temperature and radiation because of the discharge of cooling water and the absence of riparian vegetation

Biological component (river habitat and biodiversity)

- Reduced availability of natural habitats (water body, river bank, river bed, flood plain, plants)
- Reduced habitat accessibility due to disturbed ecologic continuum (especially disrupted migration paths)
- Disturbed habitat renewal due to streambed and bank stabilisation, gradient adjustments and intensive management
- Qualitative habitat degradation due to unnatural flow and sediment regimes
- Disturbance of habitat development due to extensive and/or insensitive maintenance
- Degraded riparian areas due to their functional separation from water course and extensive use within the urbanised area
- Change and loss of biodiversity (fauna and flora)

Targeting the rehabilitation of rivers is the most recent step in the long history of human interrelations with waters (cf. e.g. Boon 1992). Improving the ecological functions of waters while maintaining the anthropogenic use of them is a new approach. Previous uses of waters meant that human exploitation dominated all other potential water use. These usually affected ecological properties and limited the compatibility with other possible uses. Rehabilitation of urban rivers is a new endeavour, setting out to first of all reverse adverse ecological impacts such as changes of hydromorphological features and water quality, which have had substantial effects on aquatic habitat availability and biodiversity.

Beside ecological issues in urban areas there is also a cultural framework for water rehabilitation. This means that social, economic and aesthetic requirements have also to be considered. According to the principles of sustainability, a balancing of all aims is needed. The ecological concerns are given special emphasis due to the requirements of the WFD. The balance that needs to be achieved between these diverse and often competing requirements depends on the site-specific conditions.

Against this background different scopes of rehabilitation have to be distinguished, which are named with specific terms:

> **Restoration** is directed towards *recreating the pristine physical, chemical and biological state* of rivers. In its purest sense it means a full structural and functional return to a pre-disturbance state (Wade et al. 1998, p. 2).
>
> **Renaturalisation or naturalisation** describes the *naturalistic* way of bringing a (river-) ecosystem back to a *natural state* but without targeting the really pristine, pre-disturbance state (cf. Mendiondo 1999).
>
> **Rehabilitation** indicates a process which can be defined as the *partial functional and/or structural return* to a former or pre-degradation condition of rivers or putting them back to good working order (Wade at al. 1998, p. 2). It is dedicated to the ecologic state (biological, hydromorphological and physico-chemical) by structural and partly non-structural measures.
>
> **Enhancement** means an *improvement* of the current state of rivers and its surroundings. It aims at a general valorization of the ecological, social, economic and aesthetic properties.

Within the URBEM research project two terms are seen as most important: one concern is the rehabilitation as the overall perspective of a *partial* functional and/or structural return to former or pre-degradation conditions. The further is enhancement as the wider perspective including the social, economic and aesthetic properties. The term rehabilitation is better suited to the inevitable constraints for urban rivers than the term restoration. A return to a pristine-state of rivers in towns and cities may not be achievable. If rehabilitation of urban waters is put in a comprehensive understanding of sustainable urban development the term enhancement is used. In this case the ecological, social, economic and aesthetic multi-functionality of urban waters with their riparian areas are regarded. Against the background of the Water Framework Directive, within enhancement ecological conditions are considered of special weight.

1.4 Urban river rehabilitation in the European context

River restoration and waterfront development are in the mode, ranging from Europe over the American continent to Australia. River restoration centres have been formed to offer assistance and guidelines. A growing number of projects have been initiated during the last two decades that intend to re-establish pristine ecologic conditions and to improve the social and economic functions of rivers. One can even speak of an evolving new discipline "river restoration" and "river rehabilitation" (cf. Riley 1998). However, the vast majority of past publications on river restoration refer to schemes and processes in only rural areas.

A survey carried out in the first half of the 1990s (de Waal et al. 1995) reported that from 66 investigated projects across Europe only 11% where urban and 21% urban/rural. From 60 papers published in the proceedings of the 2000 conference of the European River

Restoration Centre (Nijland & Calls 2001) only 2 refer to urban water courses. Schemes for urban settings in the past often did not attract interest (see e.g. Hansen 1996, Zöckler 2000).

Nevertheless, at present there are a growing number of completed urban river rehabilitation schemes across Europe. In a publication on 16 river rehabilitation projects in the United Kingdom, the Environment Agency (2000) presents 7 cases that are at least partially in an urban setting. An document of the UK Institution of Civil Engineers (ICE 2003) names 14 urban rehabilitation schemes. Other publications on river restoration issues sometimes dedicate a special chapter to the problems of urban water courses. This points up the increasing meaning of these relatively new approaches. In some cases they are also backed with systematic outlines of actions (cf. Boon et al. 2000; de Waal et al. 1998 or FISRWG 1998). ICE (2003) states, "All urban water courses, no matter how small, should be considered for restoration back to nature". Although there are the limitations to the extent that one can carry out real restoration in urban areas, as already stated, it underlines the growing aim to include urban river rehabilitation in the wider subject of river restoration. The combination of both could be considered as prerequisite for a spatially continuous development of waters courses.

Table 1: Examples of urban rehabilitation programs in Europe emphasising the rehabilitation of urban waters

Program	**Description**
The banks of the Rhône river 2006 (Les berges du Rhône 2006), Lyon (F)	Until 2006 large portions of the riverbanks of the Rhône river are planned to be rehabilitated by the Lyon agglomeration authority *Le Grand Lyon*. The rehabilitation program embraces an area of about 60 000 m^2 that shell receive new functions (Le Grand Lyon (no year); Le Grand Lyon 2001).
Nature Val de Saône, Municipalities along the Saône river incl. Lyon (F)	The program is aiming at the restoration of the vegetation along the structurally stabilised riverbanks of the Saône river. The plan has been inaugurated in 1999 and will last several years.
The Blue Network (Het Blauw Netwerk), Brussels (Be)	The program aims at the restoration of several urban river courses in the Central Brussels Region: la Woluwe, Molenbeek sud (Geleytsbeek), Molenbeek nord, Neerpedebeek, Vogelzangbeek and the Broekbeek. The program is aimed at restoring hydrological, ecological, visual and recreational functions of the river corridors. (Het Blauw Netwerk 1998)
Trout 2010, Hamburg (Ge)	"Trout 2010" is a program to restore salmonid region habitats for selected streams in Hamburg–. Necessary improvements in canalised stream sections will be made through co-operation of "Adopt –a-brook-groups"(NGOs). The program meets the objectives of Agenda 21 for urban settings.
Emscherumbau (Ge)	The mining history of the Emscher region shapes the urban character of the Emscher basin in the Ruhr valley. The "Emscherumbau -Plan" has been in force since 1990 and advocates the rehabilitation of all water bodies within the Emscher catchment basin, aimed at a sustainable use of water, providing for the future needs of the region.
Isar Plan, Munich (Ge)	The "Isar-Plan" was initiated in 1995. It is a combined programme of the State of Bavaria and City of Munich, designed to improve flood defence, ecology and recreational value on the Isar river in Munich until 2006.
Stream concept of the city of Zurich, Zurich (Ch)	A clean-water concept for separating uncontaminated water from sewage channels was extended into a stream restoration concept. The goal is to "daylight" as many streams as possible, realigning them on the surface, to increase ecological and recreational values within the urban area of the city Zurich (Antenner 1999).

Several local and regional urban rehabilitation programs across Europe have been identified (see Table 1). They deal either exclusively, or in important parts with urban river rehabilitations (as in urban improvement projects). Generally the number of urban river rehabilitation schemes across Europe is still small. Thus, the survey within the URBEM research project required a great deal of effort and the involvement of many institutions and experts to receive more detailed information on these schemes and to find out their rehabilitation approach.

2 Approach

For the investigation of existing urban river rehabilitation and enhancement schemes a case study approach was chosen. Based on a survey of existing rehabilitation schemes in urban and sub-urban areas more detailed investigations were carried out for selected projects. Thus, the approach combines the representation of current urban river rehabilitation experience in Europe with an in-depth analysis of specific schemes. The survey extended over the present EU Member States, the accession countries and to schemes in other continents. Web-based and literature research, consultations with restorations centres and professional associations as well as own knowledge of completed or ongoing projects were used. Afterwards a selection of relevant schemes in the light of the aims of URBEM was carried out (see below). The selection process considered both the regional spread of the cases from a European perspective and their meaning for urban river rehabilitation from the view of supposed good practice. As a next step, relevant agencies were identified, who carried out or accompanied the schemes. These were asked to assist further investigation.

The in-depth analysis was based upon a questionnaire (see below). Due to the wide spectrum of concerns and expected differences of the site-specific rehabilitation procedures this kind of investigation was supposed to cover many different types of data and information. Thus, areas for descriptions should ensure broad information in the expected fields. Areas with categorised or parameterised data should allow a quantitative or qualitative comparison. The latter seems to be of an added value for the outcomes on the representation of certain aspects.

In the overall approach the following working steps could be distinguished:

- Survey on European and international urban rehabilitation schemes
- Selection of case studies
- Identification of relevant actors as contact persons
- Development of a standardised data enquiry form
- Enquiry and refining of data
- Analysis
- Presentation of results

2.1 Survey and selection of case studies

The research for relevant rehabilitation schemes took place via internet, email, literature and interviews via telephone. The following sources were explored:

- Regional environmental authorities (e.g. the DIREN, France), authorities of large cities, associations of practitioners (e.g. ATV-DVWK, Germany)
- Companies dealing with river rehabilitation issues (e.g. Umweltinstitut Höxter, Germany; Šindlar consulting, Czech Republic), scientific institutions or Non-Governmental-Organisations (e.g. the River Restoration Centres), private and public institutions dealing with water management
- Local authorities, personal contacts with other professionals (e.g. URBEM partners)

Institutions in the following countries were contacted: Albania, Austria, Czech Republic, Belgium, Canada, Denmark, Finland, France, Germany, Great Britain, Greece, Israel, Italy, Japan, Luxemburg, the Netherlands, New Zealand, Norway, Poland, Portugal, Romania, Russia, Slovakian Republic, Slovenia, Sweden, Switzerland, Spain and U.S.A.

Table 2: Survey of schemes considered for the choice of case studies (selection)

Country	**Case studies**	
A	Vienna, Wienfluss-Auhof Vienna, Donau	Vienna, Lieslingbach Salzburg, Alterbachsystem
BE	Brussels, Woluwe	
CH	Zurich, Brooks of the city – Albisrieder Dorfbach	
CZ	Náhon, Chrudim	
D	Amber, Vils Augsburg, Wertach - Wertach Vital Biberach, Biberach Dresden, Kaitzbach Dresden, Elbe Hamburg, Wandse Hamburg, Elbe - Aufwertung Hafenanlagen Hamburg, Alster – Hafencity Hamburg, Elbe – Elbdeiche	Hannover, Leine Leipzig, Pleissemühlgraben Munich, Isar Nuremberg, Pegnitz Ruhrgebiet, Deininghauser Bach Ruhrgebiet, Alte Emscher
DK	Aarhus, Aarhus	
ESP	Barcelona, Besos River Madrid, Pozuelo Stream	Lleida/ La Mitjana
F	Lyon, La Rize Grésieu la Varenne, La Chaudanne nearby Lyon, La Mouche	Lyon, La Saone Brives Charensac, Loire
IL	Tel-Aviv, Yarqon river	Haifa, Kischon
IT	Rom, Torbellamonaca	Florence, Torrente Mugnone
N	Oslo, Alna River	
NL	Arnheim, Lower Rhine	
PL	Krakau, Weichsel	
PT	Fervenca, Braganca	
SL	Lubliana, Mali Graben	Lubliana, Ljublianica
UK	London, Quaggy Calne, Marden	Darlington, Skerne New Castle, Ouseburn - PURE Programme
Canada	Toronto, Don (Chester Springs Marsh)	Toronto, Mud Creek
Japan	Kitakyushu, Kokumano River	
US	Washington, Anacostia – Kingman Lake Area Program Washington, Sligo Creek Storm water Retrofit	Wilmington, White Clay Creek Water Management Plan Wilmington, Christina - Riverfront

A total of about fifty urban river rehabilitation schemes, mainly from Europe, where identified. It became obvious, that there is an uneven distribution of potentially appropriate rehabilitation projects across the European countries. Whereas there are countries where it was easy to find a significant number of schemes, there are also countries where the rehabilitation of waters seems not yet to be as common. For instance, in Austria, France, Germany and Great Britain a comparatively high number of projects could be identified. In contrast, in general southern European countries usually offered only a very limited variety and are thus underrepresented in the survey. This became even more obvious after the selection process as part of the in-depth analysis.

For the choice of case studies three criteria have been defined as minimum requirements. All of them had to be met to include the scheme for a further, in-depth analysis. This restriction ensured that the selected schemes suited with the specific requirements of the URBEM research project. The criteria for the selection of the urban rehabilitation schemes were:

Objectives are surface water bodies or their section in urban or sub-urban settings.

Urban or sub-urban setting is defined by the presence of anthropogenic pressures that usually appear in towns or cities (see Chapter 1.3).

Schemes are based on the aim to rehabilitate the water body.

'Rehabilitation' applies first to ecologic functions of a water body. In addition to this, valorisation in social, economic and aesthetic means may be included in the project.

The rehabilitation has been completed or launched.

Planning is completed, all the techniques have been implemented, the costs can be stated and an evaluation of success may be available.

Further aspects of choice where needed to ensure the "good practice" character of any case study. These referred to requirements needed to sufficiently cope with the information needs stated above. In this respect, issues of applied techniques, the performed planning process, accessible monitoring data and distribution of case studies in the European countries played an important role. In practise, hardly any case study can be expected to represent good practise with respect to all of these additional requirements. The choice is even more limited when looking for a highly innovative project that has already been completed and which is furnished with well documented monitoring data and a post implementation appraisal. Nearly all rehabilitation schemes last a significant period. Thus, well-documented approaches do not contain the current state of the art and most innovative projects often are not yet well documented.

Schemes aimed solely at the purification of wastewater from urban sources have not been considered, well respecting that water quality in the past often used to be the minimum factor for the sustainable development of water bodies. Especially in accession countries, water quality may still be a limiting factor. Nevertheless, water quality is addressed by a large number of national and international legislation some of which is already in the process of implementation. Instead, the selected case studies pay attention to rehabilitation schemes addressing a complexity of issues typical of urban settings of which water quality is merely one. These are schemes of ecological improvement in difficult, but representative, urban conditions, addressing structural and functional rehabilitation of the urban water body and its adjacent environment and displaying associated planning and rehabilitation procedures. Furthermore issues of social and economic welfare – two additional urgent issues of urban water enhancement - are considered.

The intensive search for case studies across Europe and other continents taking into consideration the three criteria and as many as possible supplementary aspects have finally led to the current set of *twenty-three case* studies. Many of the schemes identified during the survey did not fit the formulated criteria. Some, however, could not be investigated due to lack of data or difficulties in data enquiry. The final set covers most countries of the European Union and some other countries. Despite intensive research, only one suitable case study could be found in the accession countries. Further projects were considered as sources of information on certain issues that could not sufficiently be derived from the case studies. This set of cases could be considered as a representative part of those urban river rehabilitation schemes that cope with the requirements formulated above. Thus, with the present investigation, for the first time a comprehensive study dealing with urban river rehabilitation schemes and methods on a European wide level has been carried out.

2.2 Standardised enquiry

An investigation of urban river rehabilitation schemes requires a comprehensive view, covering the ecological, social and economic impacts, applied techniques as well as public involvement. As an overall framework, the planning process has to be considered, ranging from the initiation of a scheme to its final monitoring and evaluation and probably continuation. This means that tasks covering different disciplines have to be integrated and put into an overall context. For that reason, within URBEM an all-embracing enquiry was carried out. Within a questionnaire a systematisation of all relevant questions was provided. The development of this questionnaire and the real enquiry demanded the involvement of various skills from both the researchers as well as those involved with rehabilitation in practice. An intense and continuous collaboration with the latter could be seen as the basic prerequisite to obtain the results presented below.

Data enquiry form

The questionnaire had to accomplish different tasks. First of all it had to ensure a robust ascertainability of the same features under varying natural and societal site-specific conditions throughout Europe and beyond. Further, the collected information should be sufficiently classified to provide a common format for a comparison between the rehabilitation schemes. Moreover, the questionnaire should also afford some space to describe unforeseen descriptions of rehabilitation targets, new tools, innovative techniques or improved procedures. Finally, the consideration of all relevant aspects mentioned above was required.

The final enquiry form consists of a preceding project outline, which summarises basic information about the project, and three main parts: The first part is dedicated to the ecological, social and economic state of the rehabilitated water, the second to the applied rehabilitation measures and the third to the rehabilitation process. An additional 'Strengths and Weaknesses' sheet provides descriptive information about the rehabilitation scheme that cannot easily be derived from the other sheets.

The three parts are represented by five sheets as follows (see Annex 1):

State before and after rehabilitation:

(A) Ecological and chemical indicators

(Ax) Additional Information on ecologic and hydrologic parameters

(B) Social and economic well-being conditions

Rehabilitation measures applied:

(C) Physical measures

Rehabilitation process ranging from before, during and after implementation:

(D) Planning process

The first three sheets (A, Ax and B) describe the ecological, social and economic conditions of the rehabilitation site and the adjacent area. This part of the enquiry delivers a comparison of the conditions before and after the implementation of the rehabilitation project. It is meant, therefore, to provide information about the effects of the scheme. The ecological data (A and Ax) were gathered referring to indicators of the European Water Framework Directive (WFD 2002) and the European Bathing Waters Directive (BWD 1976). Since most rehabilitation projects considered had been finished or begun before the WFD came into force, the classification was used without, in all cases, having available the definitive measurements according to the directive. The data was used to provide a five-stage classification under the WFD and a three-stage classification under the BWD.

Information on social and economic well-being (B) is gathered by criteria embracing different aspects of urban water rehabilitation. The classification follows a proposed three-stage ordinal scale. Sheet (C) is the basis for the documentation of the rehabilitation measures applied to implement physical changes in and along the river reach of interest. The sheet covers a wide variety of potential rehabilitation targets. It is first meant to provide information on the issues addressed. Secondly descriptions of applied rehabilitation techniques can be given based on which additional information is provided from the partners of the rehabilitation. Sheet (D) deals with issues of planning, procedure and assessment of rehabilitation schemes.

Process of data enquiry

During the selection of the case studies, the institutions in charge were asked to participate in the enquiry. This first of all meant cooperation in the delivery of data for the enquiry form. Where possible additional documents where acquired to supplement the overall picture of each scheme. Those documents also contribute to the ongoing work of other parts of the URBEM research project. The completion of the inquiry form demanded a certain effort, which meant that the contribution from for the partners from the rehabilitation practice could be significant. The wide range of requested information required the collaboration of a number of different institutions per case study. To facilitate the completion of the questionnaire, a close communication with the researcher team was provided. This normally included extensive telephone interviews and, where possible, personal visits were made. The willingness of the partners to support, finally led to a database, which gives an excellent overview of urban river rehabilitation in Europe.

3 Characterisation of the case studies

This chapter presents an overview and characterisation of the chosen case studies. It is dedicated to the range of rehabilitation tasks and general project features, before - specific topics - are considered in more detail. Table 3 shows the twenty-three case studies representing nine European countries as well as the U.S.A and Canada. They represent a wide variety of rehabilitation schemes with relevance to a European perspective.

Table 3: Cases studies chosen for the in depth investigation

European case studies	
Austria	Alterbachsystem, Salzburg Wienfluss-Auhof, Vienna
Belgium	Woluwe, Brussels
Czech Republic	Náhon (Mill Race), Chrudim
France	La Chaudanne, Grézieu-la-Varenne (Rhône region) La Saône, Lyon
Germany	Elbe, Harbour Facilities, Hamburg Emscher, Deinhauser Bach, Castrop-Rauxel Isar, Munich Kaitzbach, Dresden Leine, Hannover Pegnitz, Nuremberg Wandse, Wandsbek
Italy	Fosso della Bella Monaca Ditch, Rome Torrente Mugnone, Florence
Netherlands	Rhine, Arnhem
United Kingdom	Quaggy River, Chinbrook Medows (LB Lewisham), London Skerne River, Darlington
Switzerland	Albisreader Dorfbach, Brook Concept Zurich, Zurich
North American case studies	
Canada	Don, Toronto Mud Creek, Toronto
United States	Anacostia, Kingman Lake, Washington D.C. White Clay Creek, Wilmington, Delaware

As mentioned in Chapter 2, a higher representation of accession countries and countries from other continents was targeted during the survey. In the accession countries, except for the Czech Republic, no suitable schemes were found. In Israel, New Zealand and Japan potential schemes were identified, though the necessary data could not be obtained.

3.1 Brief description of each case study

In the following each case study is characterised in terms of the responsible authority, a brief description and the most outstanding aspects. The cases are listed in accordance with Table 3.

European countries

AUSTRIA

Alterbachsystem, Salzburg

Responsible: City council of Salzburg, Municipal Hydraulic Engineering Department

Description: Soil-bioengineering measures have been implemented at the Alterbachsystem. Habitat quality was improved tremendously, for example post-scheme there were nine different species of fish compared to one species before the project was implemented.

Outstanding: Early European project with soil-bioengineering measures and with a broad monitoring program and performance control

Wienfluss-Auhof

Responsible: MA 45, Vienna Municipal Hydraulic Engineering Department

Description: About 15 years ago, due to flood requirements and a new ecological focus in water management, the rehabilitation of the Wienfluss was started with preliminary hydrologic and hydraulic studies, a 1:1 test model and laboratory tests. Major objectives are the relocation of the stream into its original bed including the ecological enhancement of the site and improved flood protection for the City of Vienna.

Outstanding: Interesting approach including a soil-bioengineering testing reach, broad monitoring program

BELGIUM

Woluwe, Brussels

Responsible: Brussels Institute for Managing the Environment (BIME)

Description: In the early 1980s it was decided to daylight the Woluwe River, which, at that time, had completely disappeared under a four-lane city road and was diverted into a pipe at the side of the main mixed sewer line. A narrow strip between the road and housing had remained green, secured from development for potential road extension. The opportunity to use this strip to reconstruct a narrow river channel for part of the original discharge was used after the Brussels Central Region program "The Blue Network" was set up. The project has to reconcile a number of restrictions such as limited water discharge, disruptions from existing ponds, and diversion into an ancient mill – all together making the rehabilitation project a typical urban compromise.

Outstanding: Extremely restricted urban situation, original river course covered by main city road

CZECH REPUBLIC

Náhon (Mill Race), Chrudim

Responsible: Chrudim city council, board of green spaces

Description: After a long period of deterioration, an ancient millrace running through today's town centre of Chrudim was identified as the first and, so far, only (MZP CR 2003) example of urban river rehabilitation in the Czech Republic. The old masonry channel was replaced by a quasi-natural river course, modelled on the basis of international geomorphologic knowledge of rivers of comparable size, in comparable climatic and geologic/topographic conditions. Other techniques are applied in other, differently constrained, sections of the rehabilitation reach.

Outstanding: Rehabilitation of an artificial water body in a diversely restricted urban situation, utilising individual techniques and geomorphologic modelling

FRANCE

La Chaudanne, Grézieu-la-Varenne (Rhône region)

Responsible SAGYRC (Syndicat d'Aménagement et de Gestion de l'Yzeron – Cooperation board for the Management of the Yzeron river basin) SIAHVY (Syndicat Intercommunal d'Assainissement de la Haute Vallée de l'Yzeron – Inter-municipal partnership for waste water purification in the upper Yzeron river valley)

Description: The problem of mixed sewer overflows in the municipality of Grézieu la Varenne into the river La Chaudanne (tributary of the Yzeron river) was solved by a partnership developed for inter-municipal basin management. The surface and waste water systems were separated, and storm water retaining, treatment and infiltration structures installed. The SAGYRC presents an interesting organisational model for planning and implementing effective management and rehabilitation of water courses. The very young scheme (2003) already has proved its functionality in terms of reducing sewer overflow, though little definite can be stated about the ecological effects.

Outstanding: A project addressing issues of water treatment and storage, sewer overflow etc.; an exquisite example of inter-municipal cooperation for basin management (planning and implementing the management of water courses)

La Saône, Lyon

Responsible: Conseil général du Rhône (section CATER 69 - Rhône Insertion Environnement) – Regional Council of the Rhône department (Environment management section)

Description: The course of the Saône river in Lyon presents a combination of extremely confining factors: impounded navigation way, quarry stone rip rap covering steep river banks and a parallel highway degraded the water course in both ecologically and visually and restrict the options for rehabilitation. A new technique developed at the Regional Council of the Rhône department was tested, adopted and applied to cover the loose boulders allowing for the development of a site with appropriate floral and faunal biodiversity of the riverbank and attempting to enrich the structural conditions in a short part of the denaturalised impounded river section.

Outstanding: Rehabilitation techniques in extremely inflexible settings

GERMANY

Elbe Harbour Facilities, Hamburg

Responsible: City board for Environment and Health, Hamburg

Description: In the course of the reuse of a degraded harbour facility as a new neighbourhood park, parts of the harbour basin were infilled. The head of the former shipping dock has been turned into a sloping, green riparian zone. The success of this measure was put into question when residents started a public "Bathing in the dock" campaign that conflicts with the original goal of recreating a natural habitat.

Outstanding: Interesting measures for ecological enhancement at heavily degraded urban harbours

Emscher, Deininghauser Bach, Castrop-Rauxel (Emscherregion)

Responsible: Emschergenossenschaft,

Description: The collapse of the coal mining industry brought new opportunities for rehabilitation of the Emscher and its tributaries. One of those is the Deininghauser Bach. Within the entire Emscher basin major efforts are undertaken to re-establish a more natural flow regime. It is being assisted through storm water infiltration measures.

Outstanding: Comprehensive approach of rehabilitating a whole urban river basin according to WFD

Isar, Munich

Responsible: State of Bavaria, represented by the Department for water management, Munich and the City Council of Munich

Description: The city of Munich has initiated an elaborate rehabilitation effort along the city's main River Isar. It is aimed to meet new flood protection requirements, to enhance ecological quality and water quality to improve recreational values of the river and river corridor. The objective of the project was to restore the river to its former state: a wild river, shaping its own natural bed.

Outstanding: Comprehensive approach to rehabilitation covering ecological and social, as well as security aspects, utilisation of a reference and testing section

Kaitzbach, Dresden

Responsible: Technical University of Dresden

Description: This 19th century mill creek became severely degraded by carrying runoff from urban and industrial developments. A research project with a comprehensive social analysis started the rehabilitation of this brook and several projects on different sections of the brook resulted. One of them was a Dresden University of Technology student demonstration project, using soil-bioengineering to enhance the hydromorphology of the brook.

Outstanding: Comprehensive social analysis and diverse public participation tools have been used

Leine, Hannover

Responsible: Hanover city council, Board for urban green spaces

Description: In the scope of the EXPO 2000 in Hanover a rehabilitation project of the Leine river valley was implemented. High water dykes were opened to allow the flooding of the valley. Parts of the floodplain were lowered to increase the frequency and duration of flooding. Quarry stones stabilising the river banks along the insides of bends were partly removed, despite the "federal water way" status of the Leine river.

Outstanding: Process restoration in the floodway including riparian forests; combined approach – ecological enhancement in the flood plain, improved flood management and public accessibility

Pegnitz, Nuremberg

Responsible: State of Bavaria, represented by the Department for water management, Nuremberg and the City Council of Nuremberg

Description: A more dynamic course of the Pegnitz should foster ecologic functions of the urban riverscape as well as its recreational usability. Therefore citizens and historical maps were consulted to restore the first section of 14 kilometres of the river's flood plain and ensure access towards, along, and across the stream. Measures included a completely new river cross-section, restoration of meanders and islands, and a playground designed as a temporary detention basin.

Outstanding: Comprehensive urban river rehabilitation effort with wide citizen involvement

Wandse, Wandsbek

Responsible: Administration of the Borough Wandsbek, Hamburg; Division for Environmental Protection; nature protection organisation BUND Hamburg

Description: "Trout 2010" was started to create more natural habitats at small brooks and rivers. The urban brook Wandse is a pilot project for enhancement through restoration of gravel and boulder areas with pools and riffles. The public was invited to participate in this process and Brook sponsorships were established.

Outstanding: Low budget project, implemented with the help of many Adopt-a-brook-groups

ITALY

Fosso della Bella Monaca Ditch, Rome

Responsible: City of Rome, Waterdesign Rome

Description: The Borough of Bella Monaca was subject to the EU urban regeneration programme *Urban*, which is directed to the realisation of urban redesign projects, social projects etc. The programme also contained the rehabilitation of the "Bella Monaca Ditch". Goals of the project were to maintain a constant water flow, treatment of solid waste, consolidation and enhancement of the morphology and vegetation of the riverbed, giving back an adjacent area to the citizens and foster activate participation and education projects.

Outstanding: The first project in the Roman metropolitan area targeting the rehabilitation of a former ditch

Torrente Mugnone, Florence

Responsible: City of Florence, Servizio Geologico

Description: Water quality of the Mugnone Brook was ameliorated by burying a public wastewater inlet under the bank and by obtaining a natural pre-treatment. Further modifications of the riverbanks and the river bed with willow piles, boulder riprap, groyns etc. upgrade the stream morphology and improve the oxygen balance of the water. New turbulence helped riverine species to resettle in the once artificial stream.

Outstanding: The first project in Italy to enhance an urban stream in 1990

The NETHERLANDS

Rhine, Arnhem

Responsible: Rijkswaterstaat, Head office Oost-Nederland

Description: Main objective of the 'Teruglegging van de Bakenhofs dijk' (Relocation of the Bakenhof dike) project was to mitigate a bottleneck in the Lower Rhine's tributary Ijssel in Arnhem. This was achieved by a dike realignment of over 1.500 m, using the vacant area of a former brickwork factory. Locally the flood plain was widened from 0 to 200 meters. The works included improvement of habitat connections, restoration of an old Ijssel bend, and a new secondary channel.

Outstanding: Combination of flood defence measures with ecological rehabilitation

UNITED KINGDOM

Quaggy River, Chinbrook Meadows (LB Lewisham), London

Responsible: Environment Agency Thames Region South East Area, London Borough of Lewisham

Description: The purpose was to improve flood protection onsite and downstream. A concrete channel dividing an urban park was reshaped following historic information, "restoring" meanders, riffles, pools, flood plain and allowing for a natural development of the river course. Additionally the adjacent park area was landscaped to raise the public amenity value.

Outstanding: Consequent rehabilitation of a heavily modified water course in an urban park area

Skerne River, Darlington

Responsible: River Restoration Centre (RRC, Silsoe), Environment Agency Northeast, York

Description: An over 2 km long degraded reach of the Skerne river at its entrance into Darlington was selected as a demonstration site for a European Life project. Spatial restrictions from pipelines parallel to the river, power lines, housing and extensive historic spoil tipping had to be considered when implementing this scheme. Thus, in different sections different techniques were applied. The surrounding landscape was extensively reshaped, material reused, the site accessibility improved and features of safety and experience introduced.

Outstanding: Large project with innovative soft revettement techniques, good combination of ecological, landscape and participation aspects

SWITZERLAND

Albsrieder Dorfbach, Zurich

Responsible: ERZ Entsorgung & Recycling Zürich

Description: During the 1980's requirements for wastewater management and municipal cost controls resulted in the "Brook Concept Plan" for Zurich. Since then, about 14.5 km of underground brooks and springs that were previously connected with the sanitary sewage system were placed on the surface saving treatment costs and enhancing neighbourhoods.

Outstanding: Citywide effort with community involvement to daylight city creeks

North America

CANADA

Don, Toronto

Responsible: Task Force to Bring Back the Don

Description: Since the mid 1990s the city has seen many efforts to restore the heavily modified Don. The main actor was and is the "Task Force to Bring Back the Don", an independently working group of representatives from the city, diverse interest groups and citizens. The strategy for regeneration includes big scale projects and supporting small-scale projects under community involvement.

Chester Springs Marsh – Chester Springs Marsh is part of the ongoing effort to "Bring Back the Don" by restoring some of the natural habitat that once flourished in the degraded area of the valley. The restoration project was developed to demonstrate the benefits of a wetland.

Outstanding: Rehabilitating of an entire urban river basin initiated by citizens, comprehensive monitoring program during the rehabilitation

Mud Creek, Toronto

Responsible: Envision the Hough Group, City of Toronto

Description: A covered tributary of the Don River, the Mud Creek, which functions as a storm water sewer has been day-lighted and turned into a series of extended detention ponds. Now the site cleanses runoff pollution and functions as a nature education site at the newly restored Don Valley Brickworks.

Outstanding: Rehabilitation of a heavily degraded brook in combination with nature and cultural education

U.S.A

Anacostia, Kingman Lake, Washington D.C.

Responsible: District of Columbia Office of Planning

Description: Kingman Lake Area Program – the morphology of the tidal river system has been dramatically altered through seawall construction, mainstream navigational dredging and associated filling. Efforts were undertaken to manage the sediment inputs generated by upstream erosion and to restore riverine fringe wetlands.

Outstanding: One of many projects of District of Columbia's planning to improve water quality and habitat condition within the metropolitan area

White Clay Creek, Wilmington, Delaware

Responsible: University of Delaware, Institute for Public Administration, Water Resource Agency of New Castle County

Description: The White Clay Creek watershed, near Newark and Wilmington Delaware, is one of the a few relatively intact, unspoiled river systems in the highly developed corridor between Philadelphia and Baltimore. Mill Creek restoration occurred on the site of a golf course involving the "bio-restoration" of 1000 linear feet of degraded stream, including stream meanders, pools and riffles, riparian vegetation and non-tidal wetland habitat. Pre- and post restoration assessments of macro invertebrates and fish populations were conducted showing an increase in species abundance and diversity. A reduction of fine sediments blanketing the streambed was found.

Outstanding: The White Clay Creek Valley is the only national "Wild and Scenic River" designation in an urban area in the US.

3.2 Comparison of general characteristics

The selected rehabilitation schemes are all dedicated to water courses – that means linear, flowing natural or artificial more or less degraded urban surface water bodies. The spectrum of rehabilitation objectives, urban settings and pressures, size of water courses and amount of the projects in terms of costs are wide. To know about these differences is a fundamental knowledge to interpret the detailed comparison of this study.

A basic characteristic for any river rehabilitation project is the geographic and climatic background of the water. Practitioners need to take into consideration the waters natural background to be able to successfully achieve the set targets of the scheme. This is especially true since ecological aspects too will have a growing importance in urban river rehabilitation. Any improvement of water courses, therefore, needs to be carried out with an understanding of the natural basic conditions and processes, which eventually can support the efficient establishment of an improved and healthier urban environment.

For the consideration of the basic ecological framework, the European Water Framework Directive offers the concept of eco-regions, expressing the major ecological conditions of waters. Even though the concept has not yet been sufficiently backed with geographic information, a tentative classification of schemes is presented in Table 4.

Table 4: Distribution of case studies in European eco-regions according the WFD (tentative)

Case Study / **Ecoregion**	Alterbachsystem	Wienfluss-Auhof	Woluwe	Náhon, Chrudim	La Chaudanne	La Saône, Lyon, Mont d'Or	Elbe, Hamburg Harbour	Emscher, Deininghauser Bach	Isar	Kaitzbach	Leine	Pegnitz	Wandse	Fosso della Bella Monaca	Torente Mugnone	Lower Rhine	Quaggy	Skerne	Albisrieder Dorfbach	Don, Chester Springs Marsh	Mud Creek	Anacostia, Kingman Lake	White Clay Creek
European ecoregions *																							
3 Italy, Corsica, Malta														x	x								
8 Western highlands					x	x													x				
9 Central highlands	x			x				x	x			x											
11 Hungarian lowlands		?																					
13 Western plains			x													?							
14 Central plains							x			x	x		x										
18 Great Britain																	x	x					
North American ecoregions **																							
8 Eastern temperate forests																				x	x	x	x

* European Parliament and European Council (2000), WFD
** Commission of Environmental Cooperation (w. y) Map of North American Ecoregions Level I

Objectives of rehabilitation

In total 22 of the 23 case studies were implemented with the aim of rehabilitating an urban water course in its meaning as a partial functional and/or structural return to a former or pre-degradation condition with reference to its ecological state (Figure 1). Only 17 schemes, however, named *ecological improvement* as one of the main objectives (not reflected by the figure). Usually more than one main issue was named in each case study.

The prevalence of ecological issues (96 %) can easily be explained by the criteria set for the choice of the cases - of which 'ecological improvement' was one. A look at other issues of interest reveals that, in urban areas especially, *amenity and recreation* (43 %) and *urban upgrading* (43 %) play a predominant role, followed by *flood control* (39 %). Almost as important seems to be *public involvement* (35 %) and *visual enhancement* (26 %).

Remarkable is that goals of *urban upgrading* and *flood control* are reach while improving ecologic issues. On the one hand this shows a commonly held expectation of positive impacts from ecological improvements for urban areas – a correlation that has explicitly been emphasised in several case studies (Emscher, Quaggy, Salzburg, Saône and others). On the other hand the combination of *flood control* with *ecological improvement* shows a "new" quality with regard to urban river rehabilitation.

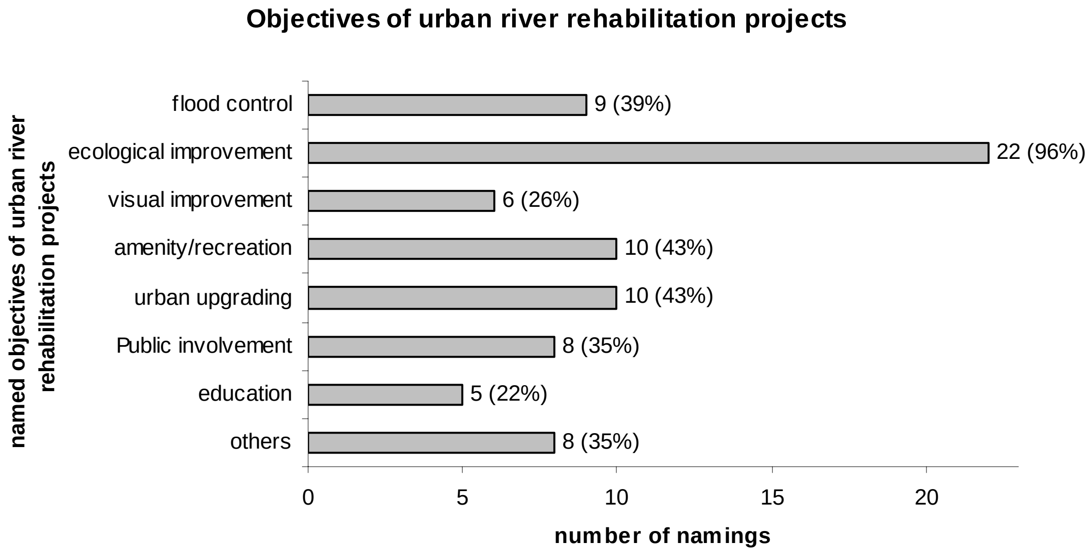


Figure 1: Objectives of urban river rehabilitation projects (multiple namings possible)

In several schemes the state of the urban environment has been seen as a factor in the overall urban prosperity. Poor environmental conditions which make a river unattractive are often stated to be a negative factor for urban enhancement processes or even limit the potential for urban revival (e.g. Emscher, Quaggy, Saône). In this context river rehabilitation appears to be seen as an opportunity for urban restructuring. The latter is also emphasised by different emerging urban renewal programs containing a strong component of river rehabilitation.

As displayed below, *flood control* activities were one of the most frequently mentioned constraints on urban water courses. This may indicate a general conflict between the goals of past flood protection schemes and the more recent aims of water course development. However, nine of the23 recent rehabilitation projects considered actively combined issues of ecological improvement and flood control – e.g. by releasing water courses from their canalised beds and shaping 'generous' new flood plains allowing the river corridor to convey a larger amount of flood water and at the same time improving habitat structure and visual experience as well as increasing the the duration of over bank flows (e.g. Skerne, Quaggy, Leine, Isar).

Looking at the targets of ecological improvement in detail a more specific picture can be drawn regarding specific ecological parameters. These target parameters are usually defined by the most urgent problems of the water course or by the most realistic options for improvement.

Fifty percent of the case studies aimed at improving ecological conditions of the water course targeted morphological conditions (Figure 2). This coincides with the perception of river canalisation (constraining river morphology) described below to be a prevailing problem of urban rivers. This target is followed in importance by *water quality* (36 %) and *hydrology and hydraulics* (32 %). Improving water quality refers to both, point- and non-point sources of water pollution, including illegal discharges, combined sewer overflows and illegal discharges from various sources. Other important targets of urban water course rehabilitation are aquatic and riparian *species* and the longitudinal *continuum* mainly in terms of fish passage. Only few target the *lateral connectivity* (sensu Amoros & Roux 1988, Ward & Stanford 1995; e.g. Leine, Quaggy).

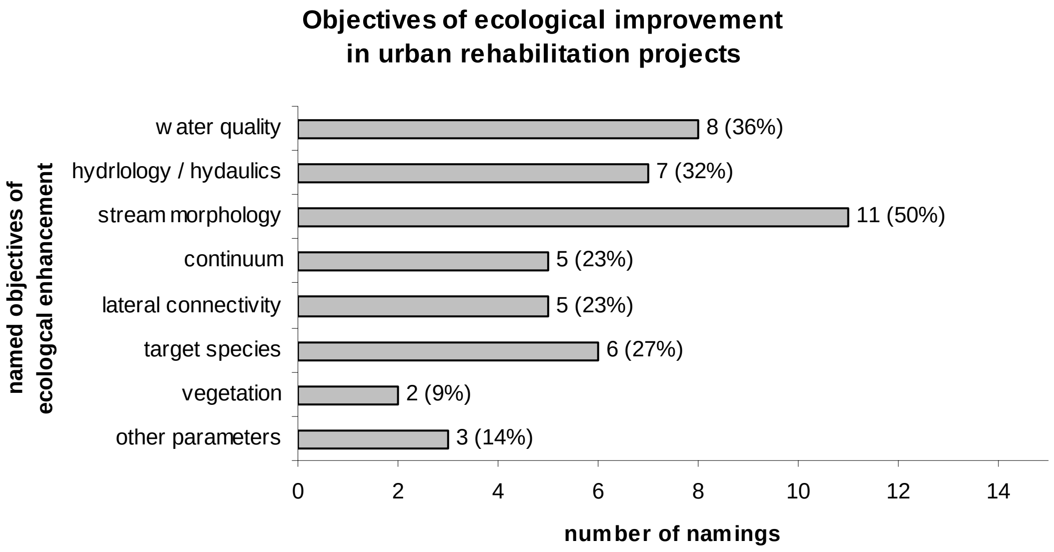


Figure 2: Objectives of ecological improvement in urban rehabilitation projects (multiple namings possible)

Urban setting and urban pressure

Urban settings impose a number of constraints on water courses that are different from those in rural areas. Rivers in almost all parts of Europe are more or less influenced by human activities or through induced changes in the river basins. Urban water courses suffer from specific urban problems, primarily caused by competing land uses, which often result in a confined channel and limit the options for rehabilitation. In particular urban constraints and pressures on water courses, with their aquatic ecosystems, have already been mentioned in Chapter 1.3.

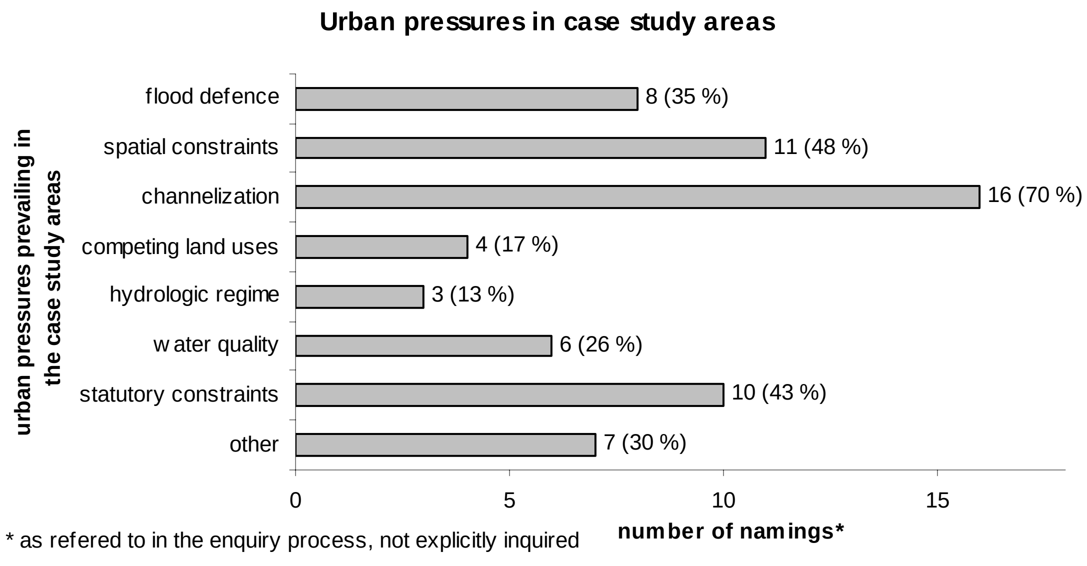


Figure 3: Urban pressures and pressures in case study areas (multiple namings possible)

During the work with the local case study partners in different European cities, a recurrent pattern of constraints and pressures could be observed in many urban settings. They may be referred as specific *urban pressures*. Figure 3 shows a number of factors that were recognised to be of particular importance in the case studies and which reflect a specifically urban context.

Canalisation implying the widening, deepening, constraining, fragmenting, culverting, and realignment of the channel, as well as bank and bed stabilisation, *was the most frequent of these urban pressures* (Figure 3). These may also be seen as one possible effect of two other important pressures: *spatial constraints* from the urban area (parallel and crossing communications, adjacent built structures) and *flood control*.

In contrast it is remarkable that *water quality* was explicitly identified as a problem in only every fourth (26 %) urban water course, whereas 36 % of the schemes named the aim of water quality improvement. On the one hand this may be connected to the ongoing improvements in the recent past, making poor water quality a constraint of less importance. On the other hand this reflects what often has been stated for the reason of site selection: those water courses which are selected for complex rehabilitation (as targeted by URBEM) are chosen as they are not constrained by water quality (e.g. Woluwe and others). Other significant pressures arise from *statutory constraints* and *competing uses*. The former encompasses mainly rivers which are used for navigation, causing restrictive river management (the latter not being a specifically urban problem, e.g. Saône, Leine) and historic preservation status e.g. in terms of protecting historic water works in and along the water courses (e.g. Náhon, Wienfluss-Auhof, Mud Creek). Both last-mentioned pressures also limit the options for urban water course rehabilitation in a special way as they make it necessary to compromise with differenty or even conflicting laws.

Size of water courses

Urban rivers which have been subject to rehabilitation have a range of different widths. The length of rehabilitated sections also differs but trends can be seen with regard to both parameters.

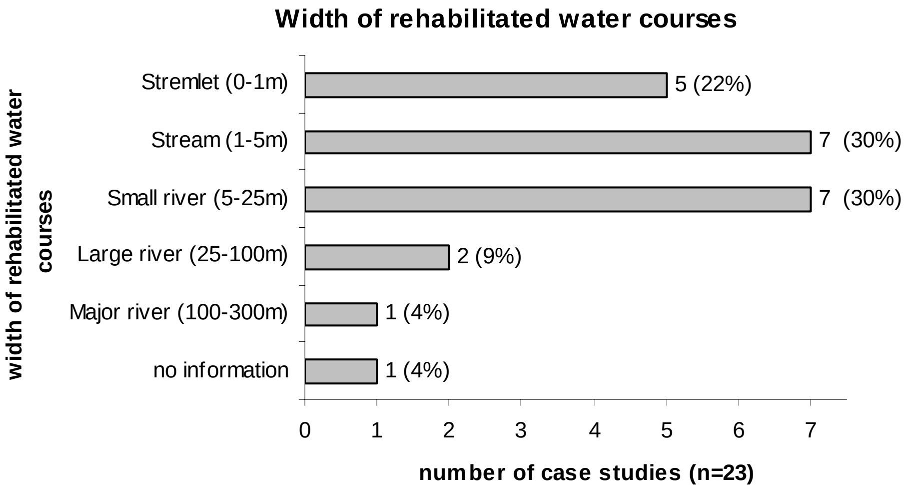


Figure 4: Width of rehabilitated water courses (classification by Huet 1949)

According to results from the investigation predominantly *streams* and *small rivers* are targeted by urban river rehabilitation projects (see Figure 4). Together these two classes make up 60 % of rehabilitated water courses followed by *streamlets* (22 %). A limited number of exceptionally *large and major rivers* (together only 13 %) are approached by urban water course rehabilitations (Arnhem, Saône).

Figure 5: Lengths of rehabilitated sections

The lengths of rehabilitated sections of water courses also show a wide rage (Figure 5). It may be concluded that urban rehabilitation reaches are generally shorter than those in rural areas. An earlier survey (cf. de Waal et al. 1995) comprising a majority of rural rehabilitation projects reaches, refers to rehabilitation reaches up to 5 km in length as "small scale". The twenty three urban schemes investigated for the present study are considerably shorter, having a mean length of about 2000 metres with a median of approximately 1300 metres.

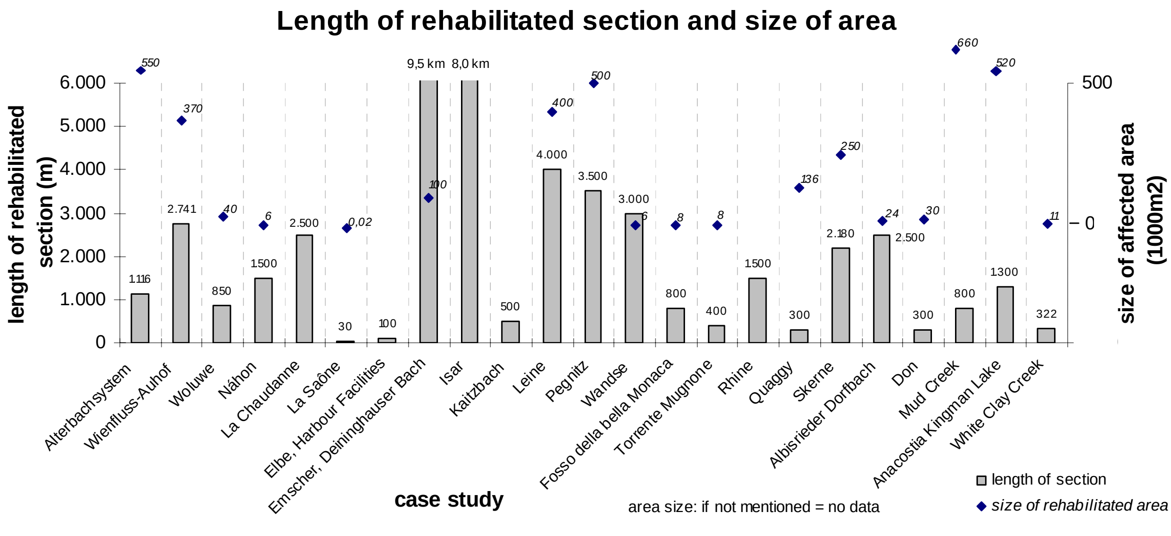


Figure 6: Length of rehabilitated sections of water courses and overall size of affected area

Fifteen schemes where found to be shorter than the average (2000 m) and only eight where longer. However, this is influenced by the fact that two cases have extraordinary and unrepresentative lengths of 8,0 km and 9,5 km whereas most of the other schemes are considerably less than 3,0 km in length (Figure 6).

Thus most schemes showed lengths of between 500 and 2000 metres - together over 50 % of all cases. One third (over 30 %) of the schemes addressed river reaches over 2000 m long. Compared to this, the sections shorter than 100 m appear to be rather less common. The latter may be explained by the impression that smaller and, due to this possibly "less spectacular" schemes are less well documented than larger ones. It may also be that due to the emphasis of this survey on complex rehabilitation approaches which have a 'good practice' character, larger schemes prevail. In fact, it can be assumed that a much higher proportion of spatially very restricted schemes may be found in European cities.

Rehabilitation projects range in scale from incorporating an entire drainage basin down to single interventions along very short reaches of a water course. Urban river rehabilitation projects very often are combined with a general upgrading of the neighbourhood surrounding the water course itself. Often the schemes also involve the landscaping of the adjacent land, the establishment of new paths or facilities for information. For this reason the land areas affected by rehabilitation projects also differ in size but without a strong correlation with the size of water course addressed (Figure 6).

Total and relative costs of urban water course rehabilitation

An aspect of the investigation was to study the costs relating to the phases of planning, implementation and monitoring of implementation projects. What the survey showed was that such a listing of costs was not possible for most rehabilitation projects. In the best case the partners could detail total costs. These however, in some cases must also be seen as approximate figures. There is no certainty that for all case studies the absolutely exact numbers where obtained. This is especially true as many rehabilitation projects were at least partly planned and implemented by public authorities operating with global budgets, and thus detailed planning and other costs were not available. Nevertheless, even if the numbers obtained may not be completely reliable and comparable they do represent a best judgement and allow comparative conclusions to be drawn.

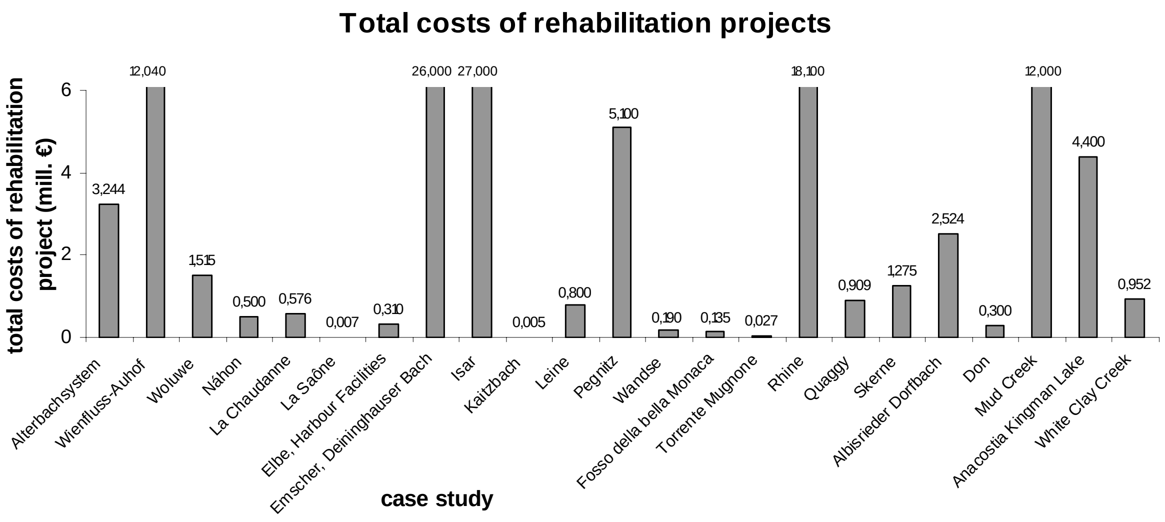


Figure 7: Total costs of urban rehabilitation projects

The total project costs turned out to be extremely variable (Figure 7). The range extends from real low budget projects (La Saône, Torrente Mugnone, Kaitzbach) costing considerably less than 50.000 Euro up to projects with costs of several Million Euro, reaching maximums of 26 mill. Euro (Emscher) and 27 mill. Euro (Isar).

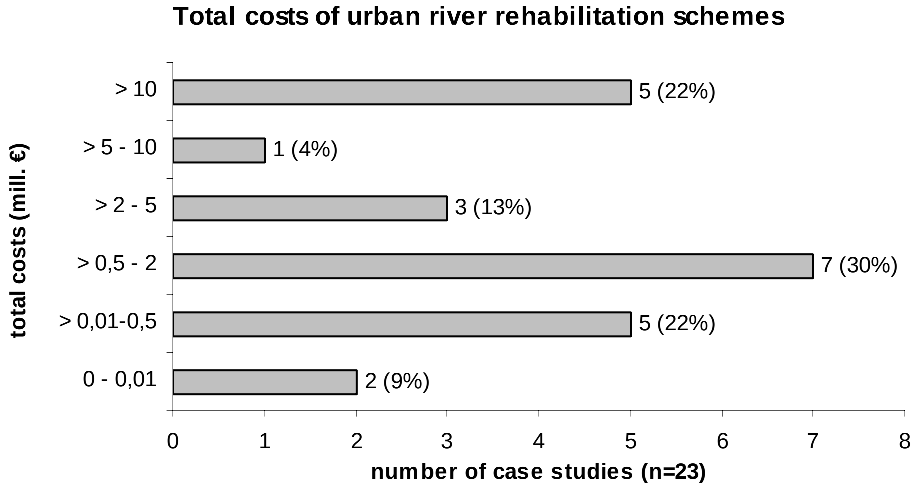


Figure 8: Total costs of urban river rehabilitation projects

However, the costs of the majority (52 %) of urban river rehabilitation schemes range between 100.000 and 2 mill. Euro (Figure 8). There were very few schemes in the survey that costs less than 100.000 Euro. Many of the projects costs were of medium scale, due to the prevailing project size, though projects with a budget over 2 mill. Euro were found to be almost as frequent. 17 % of the case studies displayed project costs ranging between 2 mill. and 10 mill. Euro while 22 % were found to have total costs over 10 mill. Euro.

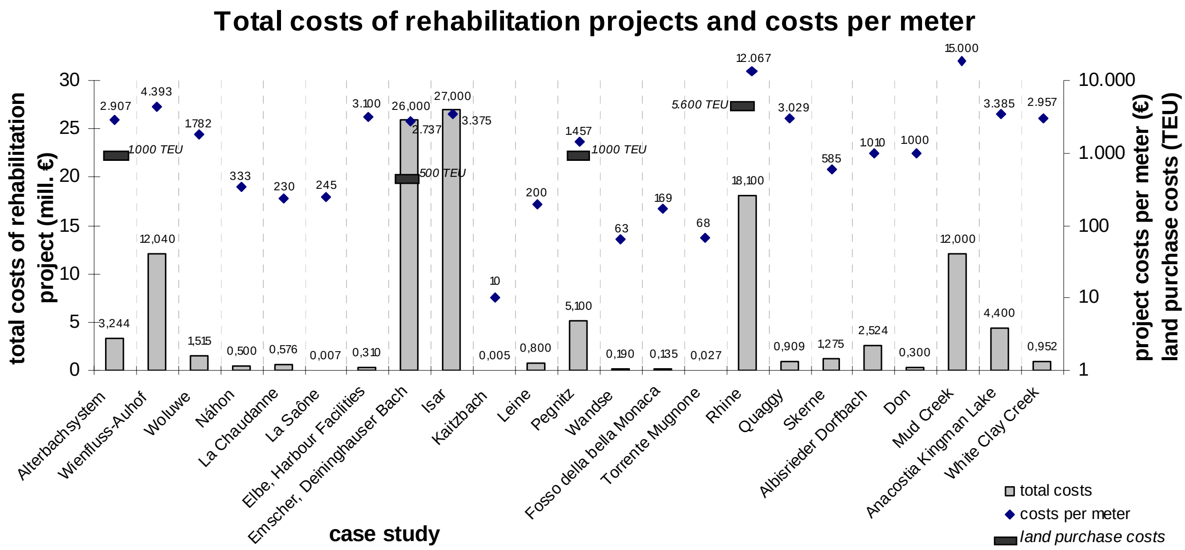


Figure 9: Correlation of total project costs and the length of the rehabilitated section

Finally, the correlations found between project costs and project size was only apparent with relation to the length of water course rehabilitated. The costs do not correlate with the size of the rehabilitation area. The correlation of total costs with the length represented by the specific costs per metre of river reach is displayed in Figure 9. This combination unveils two major trends: First it is obvious that costs of rehabilitation projects in general clearly rise with the project size: the longer the targeted reach, the higher are the total project costs. The second correlation shown is that specific project costs (Euro per metre) increase with total costs and the size (length) of the scheme. An explanation may be that bigger scale rehabilitation projects tend to have more complex goals and target functions and have a more elaborate planning process, all resulting in extra costs (such as for land purchase – see same figure).

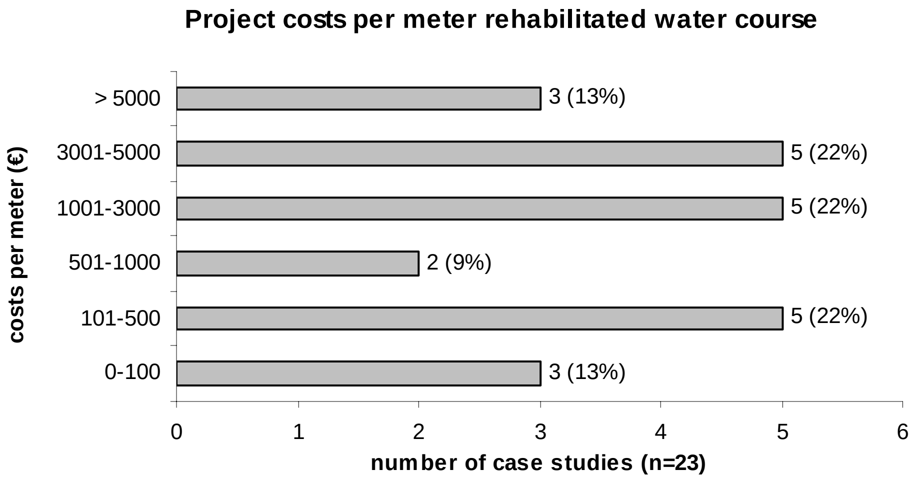


Figure 10: Costs per meter of urban river rehabilitation projects

The costs per metre of rehabilitated water course have a mean value of approximately 2.600 Euro/m but are influenced by a few extremely expensive projects. The median value for the parameter shows the more realistic picture with about 1500 Euro per metre. The cost per metre distribution of investigated schemes (Figure 10) is significantly less distinctive than for other parameters (see above). Fifty percent of urban rehabilitation projects had costs between 101 and 3000 Euro per metre. Though the distribution of schemes finds its peak in the range of 1001 to 5000 Euro (together 44 %) the lowest (0-99) and highest (>5000) project costs are not far behind, representing 13 % each.

4 Planning and implementation process

In accordance with the specific characteristics of any urban river rehabilitation scheme, the process was characterised by very individual procedures. In this study four steps have been distinguished:

1. Initiation (first idea, starting point of rehabilitation projects)
2. Planning (selection of appropriate sites, preparation of planning documentation, public involvement, decision-making)
3. Implementation (physical realisation of the scheme, implementation of techniques)
4. Post implementation appraisal (performance control)

In the following ‘initiation’ as well as aspects of ‘planning’ (site selection, decision-making) and ‘implementation’ are considered. Subsequent chapters will detail public involvement, rehabilitation techniques and post implementation appraisal.

4.1 Initiation of urban river rehabilitation projects

The recognition of problems or opportunities either for the water course or the surrounding urban area (see also chapter 3) initiates and motivates a river rehabilitation process. The recognition can take place through several stakeholders such as public administrations, private firms, non-governmental organisations (NGOs), interest groups and/or individuals. While public administration may also respond to binding legislature, the other stakeholders are usually driven by their own personal interests or the interest of those they represent. In most case studies more than one stakeholder group has been identified as being responsible for initiating a rehabilitation project (Table 5).

Table 5: Initiation of urban river rehabilitation projects

	Alterbachsystem	Wienfluss-Auhof	Woluwe	Náhon, Chrudim	La Chaudanne	La Saône, Lyon, Mont d'Or	Elbe, Hamburg Harbour	Emscher, Deininghauser Bach	Isar	Kaitzbach	Leine	Pegnitz	Wandse	Fosso della Bella Monaca	Torente Mugnone	Lower Rhine	Quaggy	Skerne	Albisrieder Dorfbach	Don, Chester Springs Marsh	Mud Creek	Anacostia, Kingman Lake	White Clay Creek	**Total YES (n = 23)**	**Total YES in %**
A	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x	x	x	x	x	**22**	**96**
B	x	x						x											x		x			**5**	**22**
C						x			-			x	x		x				x	x	x		x	**8**	**35**
D									x			x	x				x	x		x	x		x	**8**	**35**
E										x														**1**	**4**

x = yes, **?** = no clear statement

A: Public administration initiative **B**: Responding to legal demands by regulatory agency prescriptions
C: Civic stakeholder initiative **D**: Interest group initiative, **E**: Others

'Civic stakeholders' are individuals or groups without formal organisation at the time the rehabilitation scheme was being initiated (incl. private stakeholders). Under 'Interest groups' NGO's and other formally registered entities are considered (including the British 'River Restoration Centre' as a non-profit company).

In almost 90 % (Figure 11) of case studies public administration has been identified as the initiator (Alterbachsystem, Isar, Torente Mugnone, Wienfluss-Auhof). Initiation took place, either by the administration alone, or in conjunction with other groups. Important partners initiating or co-initiating urban river rehabilitation were found to be civic stakeholder initiatives (39 %) and interest group initiatives (26 %). However, it can be assumed that in most cases, the primary initiative came through civic stakeholders and civic interest groups and was in a second step seized upon and fostered by the public administration.

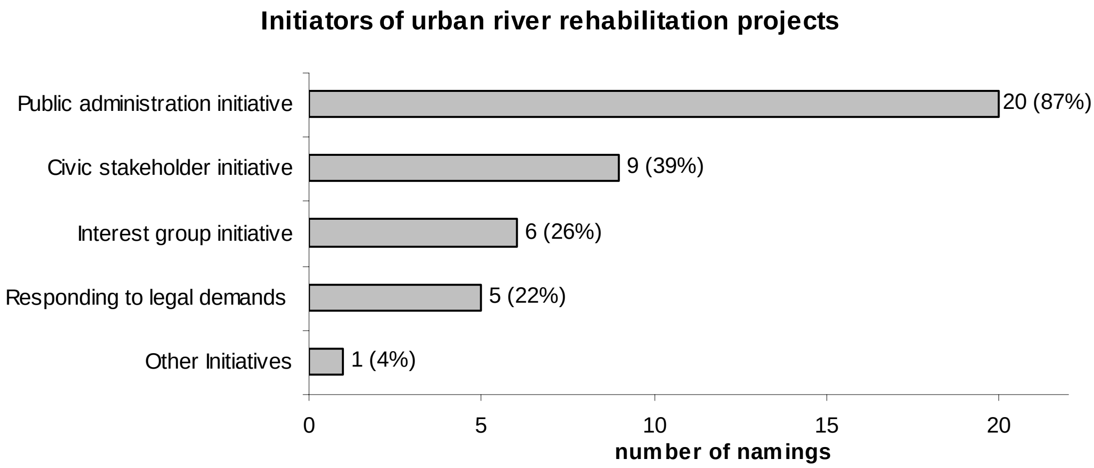


Figure 11: Initiators of urban river rehabilitation projects (multiple namings possible)

About one quarter of the initiatives of public administrations were said to have responded to legislative mandates or internal directives (see Chapter 4.3). Legal mandates such as flood control requirements (Alterbachsystem, Wienfluss), upgraded requirements for wastewater treatment (Emscher, Albisrieder Dorfbach), requirements for storm water detention (La Chaudanne) or internal directives such as designation for rehabilitation in a higher statutory planning (Pegnitz, Skerne) promoted action by community administrations. While only about 20 % of the case studies indicated a response to legal demands, it can be expected that further council initiatives have been indirectly responding to legislation or targets formulated in the process of comprehensive urban planning. Many of the case studies referred to legislation backing the restoration process. For the Wandse and La Chaudanne case studies reference was made to water quality legislature (e.g. German National Nature Conservation Law[1]). In the Náhon case the local council had issued a binding resolution backing the rehabilitation. Projects initiated by public administrations, but not responding to legal requirements either were pilot schemes (Elbe Harbour, Lower Rhine) or were financed through external financial resources or both (Fosso della Bella Monaca, Skerne).

About one third of the rehabilitation schemes were initiated by citizen or interest groups. In the case of the Pegnitz River in Nuremberg a "Young Mother's Initiative" collected signatures for floodplain rehabilitation and initiated discussions among residents. Thus the young mothers sparked action by city council. Wilmington, Delaware (U.S.), citizens were able to

[1] German Federal Law for Nature Conservation

bring about designation of the White Clay Creek under the Wild and Scenic Rivers Law, making it the only urban stream in the United States with such designation. In the "Trout 2010 Program" at the Wandse in Hamburg, the non-government nature conservancy organisation BUND[2] was involved early in the project and provided a project manager. The initiation of the program however came from an inspired public official, which was also the case for the Náhon. In the case of the Saône River restaurant owners on the opposite river bank requested an upgrading of their river view. In another example local residents called for the enhancement of the Torente Mugnone in Florence. An example of a group with special status is Toronto's Task Force to Bring Back the Don (Don River). This is a citizen group with decision-making powers that relies on professional staff paid by the City of Toronto. Their goal is to "bring back" a clean, green and accessible Don River in the city. Most of those schemes have been initiated in close cooperation with public administrations, profiting from their assistance and legal mandate.

In some cases the initiation of a rehabilitation project cannot be clearly traced back due to close cooperation of several groups from the very beginning. For example, the initiation of the Quaggy River scheme goes back to two simultaneously developed documents. The Quaggy Waterways Action Group (QWAG) in its strategic document 'Operation Kingfisher' (QWAG 1995) proposed a vision of a restored Quaggy river in the early 1990s, calling for large stretches of the river to be "Restored to Life" through naturalisation schemes. At about the same time the Environment Agency published the "River Landscape Assessment of the Ravensbourne Catchment" (NRA 1992) also identifying potential rehabilitation sites along the Quaggy River. Finally, the scheme was developed and implemented with the close cooperation of these and other partners.

4.2 Site selection

During the last two decades there has been a general increase in public interest in the rehabilitation and enhancement of urban waters. Many projects are still addressing single problems and failing to address the many faceted aspects of an urban river through a comprehensive approach covering all relevant professional levels as well as the whole river basin. Until the mid nineties only a few projects were based on a watershed wide approach, assessing the entire complexity of basin wide influences on a stream (Schueler 1995). Even today, only a small percentage of urban rehabilitation schemes (Emscher, Don River, Anacostia River, La Chaudanne, Woluwe) are backed by watershed or citywide rehabilitation programmes. However, in terms of systematic site selection, only those assessments on a higher statutory level of planning provide a basis for an effective determination of site potential for a rehabilitation purpose. A watershed wide analysis can offer the basis for the determination of limiting factors and most appropriate locations to achieve specific goals for river rehabilitation and choice of techniques. This is important since especially the selection of particularly promising sites will contribute to more effective rehabilitation schemes.

The Water Framework Directive provides a basis for basin wide river management approaches e.g. by offering the tool 'River Basin Management Plan'. This will promote further rehabilitation of urban waters, where the need for investment for rehabilitation under the urban constraints is high. A basin wide or citywide assessment will then provide an appropriate basis to select effectively the site with the highest potential of rehabilitation. This will be increasingly the case as many urban areas have already rediscovered their rivers as factors of image and prosperity. Even more emphasis will be given to urban waters when

[2] Bund für Umwelt und Naturschutz Deutschlands – German Nature Conservancy Association

European states start the implementation of the directive. Then, a systematic selection of sites with the highest potential for successful rehabilitation, taking into account effectiveness will be essential. However, even if the WFD mainly emphasises ecological criteria (biology hydromorphology, water quality) especially in urban areas also aesthetic, social and economic aspects should be considered through selection methods.

Site selection within the twenty-three case studies has displayed objective as well as subjective approaches. The majority of case studies (about 70 %) were not selected objectively (Table 6). Reasons for the choice ranged from personal commitment over recognised urban (river) problems to the opportunities and synergetic effects that rehabilitation would offer in specific locations. Constraints that limit the rehabilitation potential included, besides urban pressures, ecological, chemical, or safety problems associated with flood control (Wienfluss-Auhof, Alterbachsystem, Lower Rhine) or a combination of those (see chapter 3). Opportunities for river rehabilitation included the enhancement of locations close to urban centres through the rehabilitation of the river (Náhon, Pegnitz, Isar). Some river rehabilitation sites were an integral part of urban redevelopment programmes (Fosso della Bella Monaca, Mud Creek). Other opportunities emerged due to the removal of constraints on the rehabilitation of a river, such as a new retention basin upstream, whereby flood control measures could be reduced onsite (Isar). In the case of Emscher, open-cast coal-mining had ceased, meaning that former open, sewage channels could now be rehabilitated.

The process of recognising constraints or opportunities was different in different cases. These were either based on inventories on a higher level of government, such as regional landscape assessments (Pegnitz, Quaggy), state or city monitoring programmes, or particular flood events (Alterbachsystem, Wienfluss, Lower Rhine), through river basin management approaches (La Chaudanne), or through citizen's actions (Torente Mugnone, Albisrieder Dorfbach, Don River, Pegnitz, Quaggy).

Table 6: Selection of sites for urban river rehabilitation

	Alterbachsystem	**W**ienfluss-Auhof	**W**oluwe	**N**áhon, Chrudim	**L**a Chaudanne	**L**a Saône, Lyon, Mont d'Or	**E**lbe, Hamburg Harbour	**E**mscher, Deininghauser Bach	**I**sar	**K**aitzbach	**L**eine	**P**egnitz	**W**andse	**F**osso della Bella Monaca	**T**orente Mugnone	**L**ower Rhine	**Q**uaggy	**S**kerne	**A**lbisrieder Dorfbach	**D**on, Chester Springs Marsh	**M**ud Creek	**A**nacostia, Kingman Lake	**W**hite Clay Creek	**Total YES (n = 23)**	**Total YES in %**
A	x	x	x	x		x	x		x	x	x	x	x	x	x	x		x			x			**16**	**70**
B					x			(x)									x		x	x		x	x	**7**	**30**

x = yes, **?** = no clear statement

A: Site selection upon existing knowledge, no selection method applied **B**: Application of selection method

Only 30 % of sites have been selected by a specific, more or less comprehensive, site selection method. In these cases city wide (Brook concept, Zurich), river network based (Quaggy), or basin wide assessments (Don River, Anacostia, Emscher) determined suitable locations for prospective projects. In all those cases practicability and enforceability were important considerations for the selection of sites. The following approaches to access the enhancement potential of case study sites were found (Table 7 and Table 8). Rational approaches to site selection as found in the case studies either related to the river basin (Emscher Basin, Don Basin, La Chaudanne-Yzeron basin), the river network (Quaggy/ Ravensbourne), or the city area resp. the region (Brook concept Zurich, Albisrieder Dorfbach, Woluwe).

In general systematic site selection was based either on existing data or on specifically collected data. The latter approach was used in the Skerne case study where a selection method was formulated and the required data was defined before enquiry (see below). An important basis for data evaluation of both types of data, however, is the definition of threshold levels for the parameters used (e.g. water quality or amount of water).

Table 7: Methods and aspects of rehabilitation potential assessment found in case studies

Methods to assess rehabilitation potential	*Aspects covered*
• Area wide assessments of water body state (included in landscape planning, water body development plans, territorial development programmes, landscape assessments) • Impact analysis and assessments • Ecological studies analysing restoration potential • Pilot projects/ on-site tests • Site visits and assessment of the knowledge of stakeholders (in combination with analysis methods mentioned above)	• Significance of reducing water pollution • Potential for ecologic rehabilitation, e.g. re-colonisation • Significance of social/aesthetic/cultural/economic enhancement • Potential to reduce flood damage • Site ownership and boundary lines

Table 8: Aspects of practicability and enforceability in urban river rehabilitation projects

	Approaches	*Considerations*
Practicability	• Analysis of plan proposals • Phasing structures • Cost-benefit-analysis • Impact analysis	• Connection to other regional or site projects • Minimal preliminary study • Multiple targets considered • Cost efficiency of measures chosen • Availability of financial resources • Public outreach, publicity
Enforceability	• Personal networks • Citizen engagement • Transparent decision- making structures	• Willingness of stakeholders (citizens, owner, politicians) to cooperate in joint endeavours • Minimization of overlapping administrative responsibilities (reducing potential conflicts of interests) • Supportive legislation • Ownership of sites

No appropriate example for the latter approach was identified within the enquired case studies. The example of the Sankey River (UK) shall thus serve as reference (Environment Agency 1999). Despite the fact that the Sankey River is rural, the methodological approach is also applicable to urban river sites, though aspects considered in the appraisal may be different within an urban environment.

In the case of Sankey River (UK) the assessment tool 'National River Habitat Survey' (Environment Agency 1999) was used, to determine sites with both a need and a potential for rehabilitation. The tool was applied to ensure a dataset that was of a consistent quality (independent from the observer) and allowed comparisons of different sites. The following criteria were used to identify potential rehabilitation sites within the river network:

- Physical habitat diversity (low score required)
- Habitat modification (high score required)
- Stream energy (moderate to high score required)

Subsequently appropriate sites were identified using geographic information systems (GIS). In addition to the proposed objective of sport fishery, sites had to display fair to good water quality. The result for a number of alternatives were then analysed for aspects of practicability such as stakeholder engagement and financial feasibility.

Don Basin
To 'Bring back the Don" is a long-term and still ongoing project. For the selection of sites a phasing strategy was applied, which set priorities. According to this strategy, sites were preferred and put on priority according to following sequence: • Sites that required a minimum amount of preliminary study (i.e. potentially time-consuming environmental assessments • Sites that are of reasonable costs, • Sites selected with public involvement • Sites administered by a single agency (i.e. for reforestation projects, wetland creation, tributary stream restoration etc.) This phasing strategy continued with projects involving more complex studies and negotiations. Single redevelopment projects along the river, such as the Brickworks Case Study on the Mud Creek tributary, were integrated in this time plan as soon as their potential had become apparent. The rehabilitation of the Mud Creek itself was determined because of its significance in polluting the Don. The Chester Springs Marsh rehabilitation site was selected together with a landscape architect consultant. Initially five candidate sites were selected, which were included in a two-year public consultation process. Finally two sites were chosen at public meetings, Chester Springs Marsh being one of those.

Anacostia Basin
In the Anacostia basin sites were selected considering e.g. • Pollutant loads, • Ownership, • Potential benefits from the scheme. Multiple schemes were identified; they were moved forward when necessary prerequisites for successful implementation were fulfilled (partner buy in, permission to work in area, cost-sharing dollars available etc.). If nothing changed, the particular scheme was put on hold or was postponed.

Albsrieder Dorfbach (Zurich)
For the rehabilitation and daylighting of Zurich brooks a so called Brook Concept (Bachkonzept) of Zurich was established. The Concept analysed all historical brooks of the city on the availability of sufficient water for daylighting and on possible synergies with other projects such as the renewal of sewer channels or other construction works. A cost benefit analysis was used to establish an additional priority parameter for the selection of potential rehabilitation sites.

Skerne (Darlington)

The Skerne river restoration scheme was developed as a LIFE Demonstration Project. Two sites, a rural and an urban river, were to be chosen as demonstration sites. For this reason a site selection method was developed and an appropriate urban demonstration site has been selected from a range of possibilities.

The methodology applied comprised three stages:

- Individual site inspection and reports through a team of interdisciplinary professionals
- Appraisal of individual site potential against predetermined criteria, allocating numeric scores to the site
- Comparison of the sites, site selection

To ensure an informed judgement preceding any detailed site assessment, familiarity with the site was considered important. A preceding analysis of published and readily available data reduced the subjectivity of the first step. A detailed analysis only followed upon the selection of a potential site. The purpose of the site inspections was the observation and recording of specific information relevant to the rehabilitation potential. All experts used a standardised report format for the data collection and evaluation.

The expert appraisal that took place considered the following six parameters, which where specified through a series of measures against which compliance could be accessed:

1. Aims – site must offer potential to achieve rehabilitation goals for river and its flood plain
2. Technical – site specific project must illustrate a wide range of degradations that can be reversed, measured and developed
3. Funding – envisaged project should display short and long term economic viability through effective funding partnerships
4. Ownership – owners and occupiers must show commitment to the goals of rehabilitation
5. Promotional – the site-specific project must serve the aim for public outreach purpose
6. Risks – risk of failure connected to the project must be small and controllable

Each of those parameters was given a score indicating its compliance as excellent, good, fair or poor. The maximum score allocated was a 100, weighting the parameters 20/20/15/15/15/15. Results served to assess the appropriateness of each single site. Finally the total scores each site achieved were compared to identify the most suiting locality. (RRC 1994)

The method is assigned with a sign for caution - obtained scores should be used indicatively but not as the only reason for the final decision.

Emscher Basin

Rehabilitation sites within the Emscher basin were selected taking account of two main considerations. One was the connection with other projects or plans as, for instance, water management plans, landscape improvement projects, such as landscape parks, or urban development plans. The second consideration was influenced by the fact, that former river courses had been transformed into open sewage channels as a subsequent need for coal mining. Now those river courses are being rehabilitated starting with their headwater streams following the installation of new, closed sewer pipes.

The comprehensive rehabilitation programme for the Emscher and its tributaries has been supported by efforts to promote infiltration measures and storm water management to improve baseflow conditions in the river basin. An approach to select promising projects targeting the named goal had been found in the programme "Wege des Regenwassers" (Emschergenossenschaft 2002a), initiated under the framework of the international construction exhibit 'IBA Emscherpark'.

The water utility body for the Emscher basin sent out a call for participation to commercial and industrial firms, housing companies, schools and communities. The goal was to identify schemes demonstrating alternative storm water management techniques that had been realised with stakeholder involvement. Almost 260 responses were evaluated and interviews conducted. A project layout was developed for 45 sites.

Finally seventeen projects were chosen for implementation and financially supported by the Emschergenossenschaft according to following criteria:

- Providing a good example of an individual solution
- Good accessibility of the scheme for a broad public
- Short construction time
- Demonstration of a variety of techniques

4.3 Aspects of project management

Legislation

Legislation backing the rehabilitation process included national, state and local laws for nature conservation, water management and water use. In addition, specific (local or regional) spatial framework plans or spatial regulations and policies as well as many kinds of environmental agreements have been quoted as backing instruments. In the case of the Quaggy and Pegnitz, the local planning guidance documents respectively the landscape programme propose river rehabilitation. This kind of background was, in general, helpful for project realisation. The Water Framework Directive as an incentive for rehabilitation was only mentioned in three recent rehabilitation schemes (Emscher, Wienfluss-Auhof, Wandse). Legislative requirement for improvement of the state of waters was named only once as direct background (La Chaudanne) though it may be expected that this provided motivation in more cases. Also the framework legislation at national or state level served valuable arguments for scheme implementation (Mud Creek, Don River).

Legislation to regulate the urban river enhancement proposal and to bind administrations to the proposed objectives has been adopted in 30 % of the case studies (Emscher, Isar, Náhon, Anacostia, White Clay Creek). In the case of Emscher, special legislation was adopted, assigning to the Emschergenossenschaft, a water utility body for the Emscher basin, responsibility for the rehabilitation of the Emscher basin. Subsequently a management plan for rehabilitation of the river Emscher and its basin was adopted. In the case of the White Clay Creek, stakeholders initiated the writing in of the creek into the national 'Wild and Scenic River Programme'.

Land tenure plays another important role for effective rehabilitation implementation. It has been shown in Chapter 3 that land purchase costs only occurred in very few cases. In most cases, due to restricted financial resources, the rehabilitation was limited to public owned land or land owned by entities supporting the rehabilitation process. However, in some cases the appropriate land tenure had to be established prior to implementation. In the Náhon case, before the local abatement was adopted, the site was municipalised (before it was owned by the regional river management authority). The latter was necessary to meet requirements for funding by state programmes. In the Woluwe case, the land necessary for the creation of the new river channel was secured by a leasing agreement between the Brussels region and the proprietor.

Financing

Identification of available financing sources is a vital step in any evolving river rehabilitation scheme. Most of the case studies (74 %) took advantage of multiple financing sources (Table 9). Only four schemes were financed exclusively from one single source. The funding sources involved budgets and programmes at different administrative levels. European, national, regional and local budgets had very different shares in the case studies (Figure 12).

In 83 % of the case studies rehabilitation was supported financially by local administrations (Figure 12). The proportion of local funding varied from almost 100 % (Albisrieder Dorfbach) down to 10% (Alterbachsystem).

All twenty three rehabilitation schemes relied on public financing. Among the nineteen European case studies only five (Wienfluss-Auhof, Wandse, Quaggy, Kaitzbach, Fosso della Bella Monaca) included private funding. In two instances this meant compensation payments for other projects by private companies (Quaggy, Wienfluss-Auhof) that could be integrated into the budget. For the Skerne project, private financing became available for additional measures also from compensation payments when the initial scheme was almost completed. A private company had discovered the opportunity for image enhancement as a result of participating in a successful river rehabilitation.

Table 9: Sources used for financing urban river rehabilitation schemes

	Alterbachsystem	Wienfluss-Auhof	Woluwe	Nâhon, Chrudim	La Chaudanne	La Saône, Lyon, Mont d'Or	Elbe, Hamburg Harbour	Emscher, Deininghauser Bach	Isar	Kaitzbach	Leine	Pegnitz	Wandse	Fosso della Bella Monaca	Torente Mugnone	Lower Rhine	Quaggy	Skerne	Albisrieder Dorfbach	Don, Chester Springs Marsh	Mud Creek	Anacostia, Kingman Lake	White Clay Creek	**Total YES (n = 23)**	**Total YES in %**
A	x	x		x	x	x		x	x	x	x	x		x	?	x	x	x		x	x	x	?	**17**	**74**
B			x				x						x						x					**4**	**17**
C	x		x	x				x			x	?	x			x	x	x	x	x				**11**	**48**
D		x								x			x	x				x		x	x		x	**8**	**35**

x = yes, **?** = no clear statement

A: Multiple budget sources projects **B**: Single budget source projects **C**: Additional funding through public rehabilitation programs **D**: Private sponsorships

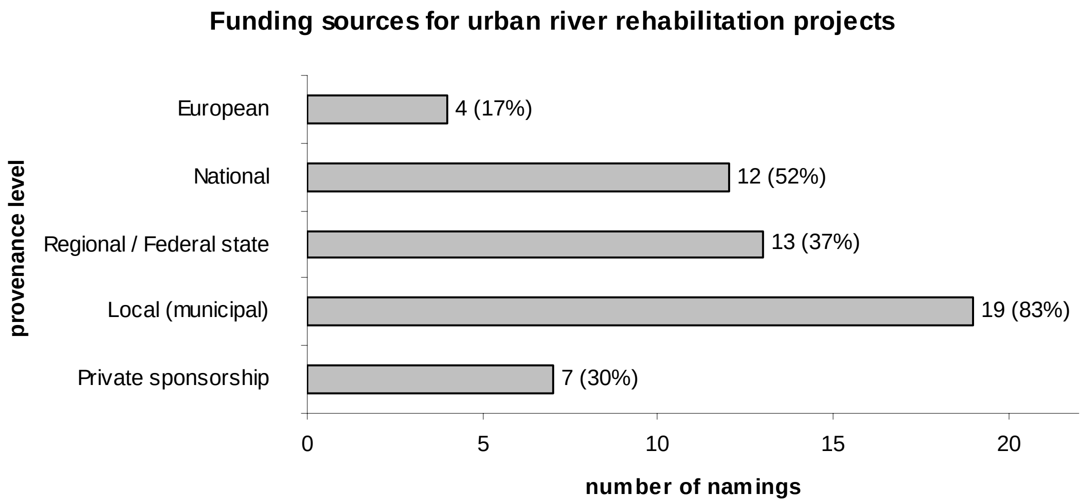


Figure 12: Funding sources for urban river rehabilitation projects

Eleven schemes were at least partly funded by one or more rehabilitation programmes, whereof only six were directly related to water bodies. However, none of the funding programmes explicitly addressed urban river rehabilitation.

How problematic the funding process can be for the often not yet established issue of urban river rehabilitation can be illustrated by the Náhon scheme (Czech Republic). For the rehabilitation of the old mill race (Náhon) initially it was envisaged that two national programmes would provide funding. However, the state programme promoting river restoration did not respond to urban water courses rejecting the proposal. The national nature restoration programme also did not address urban areas. In addition funds for the restoration of cultural heritage could not be applied as the millrace was to be rehabilitated ecologically and not only restoring the historic channel. Finally the rehabilitation project started with financial resources from local budgets and was later given an exceptional priority by the environmental Minister who visited the site after completion of the first project phase and enabled funding of the project through the Nature Rehabilitation Program.

In general, the complexity of funding sources seemed to correlate with the complexity of the funding process. In many cases collaborations of numerous partners led to a multitude of goals and often additional funding was required to cope with these. The combination of different targets often challenged the funding process but sometimes also provided an opportunity in terms of allocating finances from multiple sources. Often resources could be allocated more easily for currently more common urban purposes. These can provide a significant contribution to the budget necessary to meet the ambitious goals connected with the rehabilitation of urban rivers and their environment. As shown in Table 9 funding for most schemes had to be secured from more than one or two sources. It also seems to be not unusual that budgets have to be extended after starting the implementation.

However, detailed information on funding sources and the process of their allocation could only be researched in a few cases. Often rather rough calculations were obtained which allow a general overview but do not highlight the whole issue. As one of few exceptions, the Quaggy case study provides a good picture of a complex funding process (see below).

As financing of urban river rehabilitation projects often was mentioned as a very important limiting factor for the realisation of schemes, in some of the case studies alternative ways had to be sought. Where not enough funding could be raised, a reduction of project costs was attempted. In some case studies this could be achieved through collaboration with student groups, non-governmental organisations and volunteers without profoundly changing the project's attitude. But sometimes financial shortage also resulted in a reduction of project size. In such cases monitoring and performance control are usually omitted in first place, to keep project costs as low as possible without reducing physical measures. However, the latter should not conceal the fact that often no monitoring or performance control was foreseen from the very beginning.

Quaggy (London)

The rehabilitation of the Quaggy river at Chinbrook Meadows in the London Borough of Lewisham started with general ideas to change the ecologically adverse situation of the concrete lined river. During the planning process and with the growing number of project partners it became apparent that river ecology was only one problem worth attempting. The total urban parkland at Chinbrook Meadows needed an upgrading of which the Quaggy river would become a key element.

Different project partners contributed ides ranging from the ecological nearly restoration of the water course, to improved flood protection, aesthetically distinct and socially safe landscaping, refurnishing with lighting, paths, seats and toilets, educational and sports facilities etc.. All these purposes not only made the rehabilitation project a master plan but also required extra funding.

"The feasibility and planning phases of the project budgeted the total costs of the proposed improvements at € 1.483.970. Of this amount, € 1.120.756 or 75 % was already secured, with a *further* € 363.214 or 25 % to secure. Given that most funding was available, the project commenced whilst fundraising took place.

The funding shortfall was for two areas of activity; the sports facilities and landscape elements. The sports facilities required a further € 115.024 whilst implementation of the landscape design a further € 248.769."

Additional funding sources were identified by a feasibility study. "Ultimately it took eight months for the funding to be secured.

The budget increased by about € 248.769 during the project's implementation as it responded to emerging community needs. This amount was covered by the ongoing fundraising activity." (Changing the Channel 2003, p. 8-9; currency adopted)

Final Funding Partners:

RIVERWORKS FEASIBILITY	
Section 106	21.840
Groundwork PDF	7.280
Subtotal	**29.120**
RIVERWORKS IMPLEMENTATION:	
London Borough of Lewisham capital receipts 2002	190.132
Third Party Contribution to Onyx (LB Lewisham)	28.268
Onyx Environmental Trust	248.769
Section 106	65.520
SRB6 urban forestry	18.200
Environment Agency	328.631
Subtotal	**879.520**
OTHER PARK ENHANCEMENTS:	
London Borough of Lewisham capital receipts 2000	58.240
Glendale investment programme	454.272
Glendale Sports investment	40.404
Sport England (TBC)	157.456
Subtotal	**710.372**
OPENING EVENT:	
London Borough of Lewisham Communications	2.912
Groundwork SRB6 Development	2.912
Environment Agency Communications	2.912
Greater London Authority	364
English Nature	728
Subtotal	**9.828**
Total income	**1.628.840**

* Funding partners involved from the outset

** Partners brought on board through the fundraising process.

Organisation

Legislation and financing can function as limiting or facilitating factors for a successful rehabilitation. In addition, well organised steering and decision-making structures, as well as the quality of planning, determine the effectiveness and success of any rehabilitation project.

Establishment of transparent organisational structures and regular communication are an important part in comprehensive rehabilitation approaches and provides a stepping-stone towards successful implementation. Some forms of interdisciplinary, inter-agency or inter-departmental cooperation, especially set up for the urban enhancement schemes, could be identified in almost all case studies. For instance interdisciplinary project groups were formed for the Emscher, Isar, Alterbachsystem, Wienfluss-Auhof, Skerne, Quaggy, La Chaudanne schemes. In the Náhon and the Don River case studies the official authorities responsible for the project were supported by private consultants.

Interdepartmental task forces were established for the implementation of schemes in the Elbe, Albisrieder Dorfbach and the White Clay Creek case studies. Temporary project offices were run for the Fosso della Bella Monaca and the Kaitzbach, engaging diverse professionals. These included hydraulic engineers, geologists, biologist, environmental experts, civil engineers, landscape architects and landscape planners, urban designers, marketing and economy experts, transportation planners, and historians. For the realisation of the Isar, Wienfluss-Auhof, Skerne and Alterbachsystem schemes, cooperation with research institutions, such as universities, were valued. In some rehabilitation projects, additional external private project planners were employed on a contract basis (Elbe, Emscher). In almost all cases a single person or a very small group of professionals took the central responsibility for the realisation of the schemes. Based on experience from various river rehabilitation schemes, a set of characteristics of successful implementation process can be outlined (cf. e.g. FISRWG 1998, Entsorgung und Recycling Zürich 2000). These characteristics where at least partly met by all the case studies presented:

- Central responsibility in one person
- Thorough understanding of planning and design documents, laws and regulations
- Familiarity with the site and its biological and physical framework
- Communication among all parties involved in the project action and an inter disciplinary approach.
- Involvement of stakeholders (see chapter 8) to increase acceptance
- Monitoring and success controls

Timeframe

The different case studies evolved in very differing time frames. For many of the schemes the original ideas date back to the time before 1990 – probably as reflection of the global environmental movement during the 1980s. Nevertheless, acting on these ideas was often not started until years later (Figure 13). In most cases (70 %, of the twenty case studies that responded) initial ideas for the rehabilitation were at least 10 years old (1993 and earlier) whereas only four schemes where initiated between 1993 and 1998. Only two of the schemes were initiated in 1998 or later. However, the low number of more recent projects first of all reflects the defined requirement to consider completed schemes only (chapter 2). Many more schemes have been initiated recently that have not yet been completed and could not, therefore, be considered by the study.

Of the schemes initiated before 1993, only 8 out of 13 had started the planning process in the same period of time. This once more points out the delay between the initial idea and the start of the planning phase. About 30 % of case studies had started planning activities in 1998 or later. In contrast to the initiation, the implementation of most case studies has taken place during the past 5 years. Only four case studies where implemented before or during 1993 and 6 (26 %) between 1993 and 1998. Those numbers indicate a positive trend for the implementation of urban river rehabilitation projects.

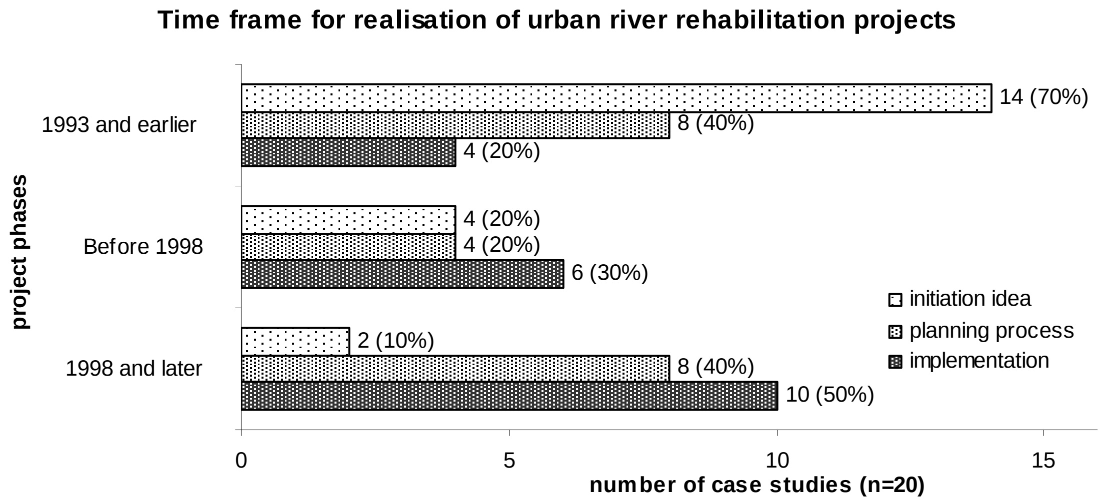
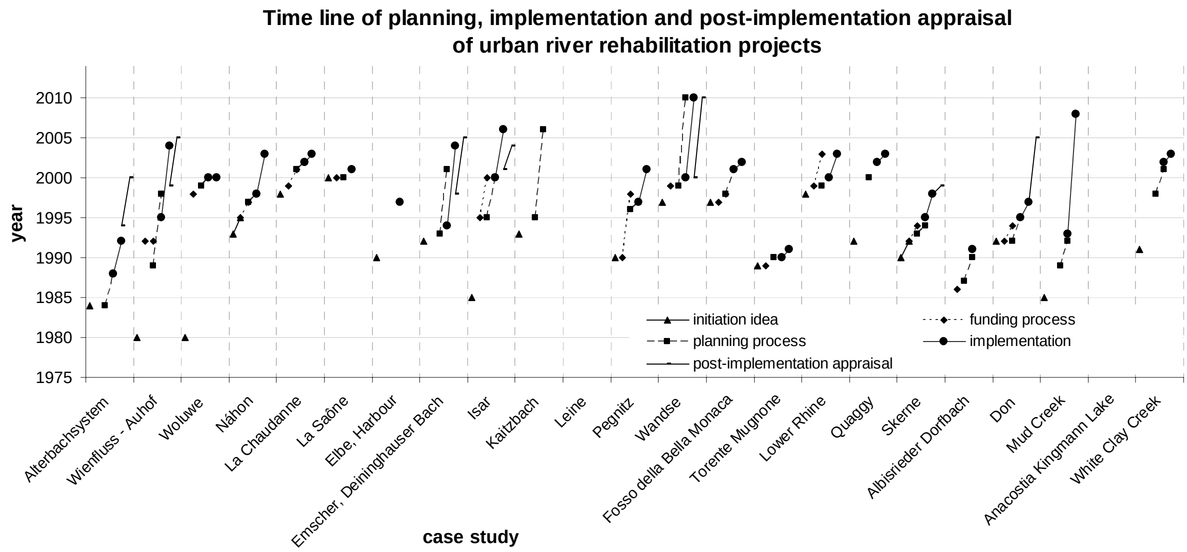


Figure 13: Time frame for realisation of urban river rehabilitation projects



* Lines indicate the temporal course of realisation phases in each case study, starting left below (begin of phase) and ending right above (end of phase)

Figure 14: Time line of planning and implementation of urban river rehabilitation projects

The average duration from initiation to implementation of a scheme was between 6 to 8 years, varying from a few months (La Saône) up to about two decades or more (Isar, Emscher - Deininghauser Bach). Within these time spans the period required to put the funding in place averaged 1,7 years, varying from a few months to 5 years. The average duration of the planning process was 2,6 years, varying from a few months up to 9 years, and implementation took an average of 2,9 years, varying from a few weeks (La Saône) to 15 years (Mud Creek). Longer time periods usually were connected to basin wide or citywide programmes, while shorter time periods related to less complex, site related projects.

The phases of initiation, funding, planning, implementation and performance control display unique sequences for each case study (Figure 14). At least to some degree phases often run parallel. A straightforward sequence of consecutive project phases, such as in the Skerne River case study was rather seldom observed. However, schemes in which all the phases ran in parallel ,as in the Wandse case study, were exceptional. The latter is the result of an approach mainly relying on the implementation of the rehabilitation scheme with brook sponsorships. Overlapping phases of planning and implementation were also found to be characteristic for large schemes, where the rehabilitation site was divided into several sections and implemented in phases. In some cases the experience of implementation was incorporated into the planning of the next river rehabilitation section to achieve better quality and efficiency of the measures taken.

4.4 Site management and maintenance

Management and maintenance of rehabilitation sites is an important, though usually neglected, part of the rehabilitation process. Any site in an urban area usually receives some maintenance. Rehabilitation schemes aim at a change of the current state of urban waters and thus may require a different management and maintenance of the water body after implementation. Depending on the maintenance prior to the scheme and on the targets and type of the installed scheme, maintenance can be lower or considerably higher than before. Therefore management and maintenance costs are of crucial importance when discussing river rehabilitation (cf. de Waal 1998). For this reason long-term management and operation costs should be considered as early as possible in the feasibility analysis when preparing rehabilitation schemes.

However, as soon as public administrations are involved, matters of urban river rehabilitation often are integrated into the routine tasks of the assigned staff. As administrations usually work with global budgets, a part of the costs that were incurred in carrying out the schemes are difficult to masses. This applies first to all kinds of services that administrative staff is commonly involved in during the implementation, such as coordinating public involvement, distributing public information, supervising volunteer teams, but this also applies to tasks like monitoring or the long term maintenance of rehabilitated sites (Wandse, La Saône, Náhon, La Chaudanne, Leine, Skerne, Don River etc.).

In most case studies resources for administration and maintenance before and after the implementation of a rehabilitation scheme could not be determined in detail. Usually only qualitative estimations could be given by the case study partners. According to the information obtained, maintenance efforts after rehabilitation may not have changed in all cases. Commonly it has been stated, that a more natural state after rehabilitation has shifted maintenance tasks and decreased costs. This can be ascribed to the frequent objectives of incorporating dynamic riverbeds and more natural embankments, which ensure a less intensive maintenance regime. Simultaneously this often allows and actually promotes bank and river bed erosion, natural river bed relocation, woody debris in the river channel, more natural vegetation along river banks and as well as in the flood way where adjacent land use is not endangered by flooding (e.g. Pegnitz, Isar, Skerne). In mid-term maintenance expenditure on the river channel can also decrease in cases where mainly soil bioengineering measures were applied and were an at least semi-natural discharge regime ensures that in-stream structures are self-sustaining. In some cases volunteers conduct maintenance and monitoring tasks (Wandse, White Clay Creek).

However, maintenance costs were not decreased in all cases. As could be shown, rehabilitation projects often are initiated in socially, economically, aesthetically or ecologically (or combined) deprived areas where prior to rehabilitation no maintenance had taken place. In such zero-maintenance areas, maintenance had to be inaugurated to maintain the newly established features (e.g. Náhon, Woluwe, La Saône)

Even daylighting and separating clean brook water from sewage water can save significant amounts of community money. In the long term, money can be saved by the separation of clean river water from the sewer network thus decreasing maintenance for the sewer system and for the more effective operation of the sewage water treatment plant (e.g. Albisrieder Dorfbach in the City of Zurich - this finding was also confirmed from other schemes not considered by the study). The benefit of decreasing sewage purification expenditure is a very good illustration of why it is neceassary to carry out a cost-benefit analysis for urban river rehabilitation projects.

Site specific maintenance of rehabilitation sites in some cases was facilitated by management or maintenance plans (Albisrieder Dorfbach, Leine, Quaggy). These included information on future development goals of the water course and proposed the necessary maintenance regimes. These plans specify time points and intervals, location and responsibilities for maintenance. Often maintenance tasks are handled through contracts to companies maintaining other parts of the water courses or green spaces (e.g. Náhon, Woluwe, Albisrieder Dorfbach).

5 Rehabilitation techniques

The achievement of the targets of urban river rehabilitation (Chapter 3) requires appropriate techniques. They have to be capable of providing ecological rehabilitation taking account of spatial pressures, aesthetic and recreational aspects as well as safety features. Therefore, techniques or combinations of them often need to provide a compromise between ecological, social and economic requirements (Chapter 3.2). This is the reason why urban river rehabilitation partly consists on specific techniques or certain combinations of techniques. During the selection of case studies for this study, the application of such innovative techniques was an additional criterion for the choice of case studies. The innovation could be indicated by explicit testing of adapted or new techniques in pilot sections (Isar, Wienfluss). Moreover, the utilisation of hydrological models (Emscher, Skerne) and hydromorphological models (Náhon) was interpreted as an indicator of individual technological solutions. It is likely that the availability of a hydrological and hydromorphologically sound basis for the choice of techniques will assist in improving river ecology in a most effective way. These approaches also guide towards the consideration of reference conditions, as e.g. required by the Water Framework Directive.

Depending on local constraints of a water course and the targets for its improvement urban river rehabilitation must furthermore consider basin wide approaches including measures in the watersheds of urban river sections as well as techniques for intervention along or inside the water courses. Also, different issues of urban water rehabilitation are important, ranging from hydrology to biodiversity and including societal issues, public health and safety, social and amenity values.

In this chapter the following target areas of urban river rehabilitation are presented with their respective techniques found in the case studies:

- Hydrology and hydrodynamics
- Morphology and connectivity
- Water quality
- Biodiversity
- Public health and safety

Each subchapter provides a table with an overview of the techniques which have been applied in the case studies. It has been found that techniques mentioned by case study partners did not always follow a standardised nomenclature. Many commonly described techniques were adapted to site specific conditions. In many cases a conglomerate of more than one technique was used. Therefore, tables are not exhaustive and include only techniques which could be clearly distinguished.

To provide a basis for further understanding annex 2 provides short descriptions of each technique. Where appropriate, site specific examples are given. In addition to techniques, combinations of urban river rehabilitation are described. They allocate, diverse non-detailed techniques and are marked with (S) for strategy.

5.1 Techniques to improve hydrology and hydrodynamics

An important rehabilitation target backed by the WFD is the improvement of aquatic and semi-aquatic habitats. These are largely dependent on the improvement of hydrological processes of the river. Hydrological processes determine the ecologically relevant minimum discharge, possible flood waves, the matter fluxes, the drift of organisms and others. Their importance for the stream morphology will be considered in chapter 5.2.

Table 10: Techniques used for improving hydrology and hydrodynamics

Techniques	Alterbachsystem	Wienfluss-Auhof	Woluwe	Nâhon, Chrudim	La Chaudanne	La Saône, Lyon	Elbe, Hamburg Harbour	Emscher, Deininghauser Bach	Isar	Kaitzbach	Leine	Pegnitz	Wandse	Fosso della Bella Monaca	Torente Mugnone	Lower Rhine	Quaggy	Skerne	Albisri. Dorfbach	Don, Chester Springs Marsh	Mud Creek	Anacostia River, Kingman Lake	White Clay Creek
Ponds w. ext. detention								x					?							x		x	x
Modular-paving blocks																						x	
Infiltration basins					x																	x	
Trenches / Dutch drains																						x	x
(S) Detaining peak flows		x						x											x			x	x
Dry detention basins		x			x														x			x	x
Wet detention basins																						x	x

The hydrological regime of urban waters is heavily influenced by impervious surfaces, but also through water withdrawal. Impervious surfaces increase the volume and velocity of runoff, and, therefore, the frequency and magnitude of peak flows. This can result in bank and bed erosion as well as water pollution through polluted runoff from urban surfaces and combined sewer overflows (Chapter 5.1). In addition groundwater recharge is reduced and base flow is decreased, additionally increasing pollutant concentrations in dry seasons. As consequence, there are a wide range of impacts on the ecological systems of waters. Water withdrawal for industrial, recreational or other purposes (e.g. hydropower) reduces the amount of available water. This especially affects the ecologically determined minimum discharge and hydromorphological processes.

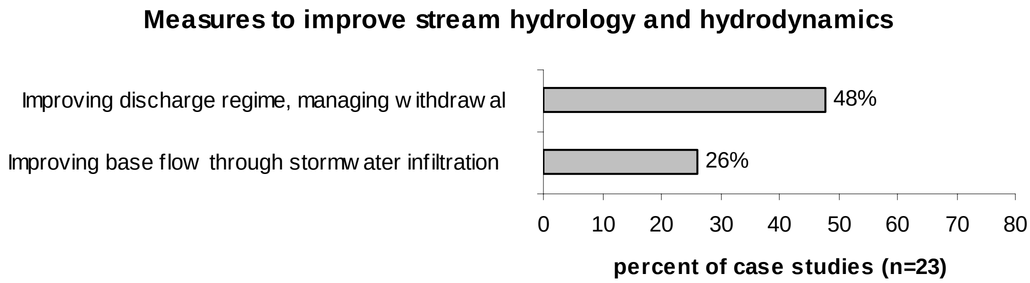


Figure 15: Measures to improve stream hydrology and hydrodynamics

Approximately 50 % of the case studies involved measures to improve the discharge regime, mainly by storm water management techniques, but also measures to manage water abstraction. An example of the latter is the case of the Isar river, where new contracts with a hydropower plant decreases water abstraction and increases the ecologically relevant discharge. Also, storm water management techniques were used for the enhancement of base flow in 26 % of the case studies (Figure 15).

Storm water management techniques applied throughout urban areas are vital to re-establish a more natural hydrological regime. These include techniques to lessen the volume of runoff close to its source, techniques to detain peak flow, and techniques to maintain groundwater recharge. In most cases those objectives overlap and also contribute towards the objectives of water quality improvement.

Measures to lessen the volume of runoff close to its source in urban areas include vegetated roofs and permeable surface materials, such as *porous pavements*. Both can be retrofitted to existing roofs and parking areas. Groundwater recharge can be achieved through the use of surface infiltration of runoff through below ground infiltration devices and by reducing the proportion of impermeable surfaces in the basin. The case studies include the use of *infiltration basins* and *gravel filled trenches.* Decentralised measures to detain peak flows are *dry (ponds) detention basins* and *wet detention basins*, which provide multiple uses such as aquatic habitat and water-based recreation. Specified measures vary from "managing discharge from a detention basin in accordance to natural runoff" (La Chaudanne) to a "future master-planning for the catchment area" (Wandse).

5.2 Techniques to improve stream morphology and connectivity

Morphological features of urban rivers are often heavily altered in densely used urban spaces and spatial constraints on urban water courses. The urban demand for space and security of land use may result in

- culverts
- bank and bed stabilisation
- flood control dams and
- levies to protect adjacent land.

These alterations lead to a dramatically disrupted ecological integrity and result in a loss of species and other ecological properties. In addition, uniform urban rivers are of low aesthetical value and can even devalue the surrounding urban area (cf. Chapter 3). Today there is a growing support and even a demand for multifunctional river corridors, which calls for a diverse morphological structure supporting multifunctional demands. This attitude is most prominently emphasised by the European Water Framework Directive. Besides providing ecological qualities, urban rivers have to cope with economic, aesthetic and recreational requirements.

Instream morphology is a major factor of habitat quality (c.f. Jungwirth 1986; Kern 1994; Madock 1999, Lammert & Allan 1999; Petts 2000). Since instream habitats are largely determined by the coincidence of water quality and morphological features, only morphologically appropriate waters can make use of good water quality to reach the best possible ecological state. Connected with stream morphology, but going beyond the surface structures of bed and banks, the connectivity of waters plays an important role in stream ecology. Closely related to the morphological type of water courses, connectivity describes the relationship of waters to their surroundings, which include riparian habitats as well as upstream and downstream sections of a river. This pays respect to the fact that the ecology of water bodies are largely influenced by the availability and accessibility of more or less distant habitats and by permanent and periodic interrelation of waters and their biota with their surroundings and vice versa. According to the serial discontinuity concept (Ward & Stanford 1983; 1995) three directions are generally to be distinguished and will serve as structure for presenting respective measures:

- *Vertical connectivity – describing the interrelations with the (sub surface) riverbed*
- *Lateral connectivity - describing the interrelations with banks and flood plains*
- *Longitudinal connectivity - describing the interrelation along the waters main axe*

Table 11: Techniques used for improving stream morphology and connectivity

Techniques	Alterbachsystem	Wienfluss	Woluwe	Náhon, Chrudim	La Chaudanne	La Saône, Lyon	Elbe, Hamburg Harbour	Emscher, Deininghauser Bach	Isar	Kaitzbach	Leine	Pegnitz	Wandse	Fosso della Bella Monaca	Torente Mugnone	Lower Rhine	Quaggy	Skerne	Albisrieder Dorfbach	Don, Chester Springs Marsh	Mud Creek	Anacostia, Kingman Lake	White Clay Creek
Techniques to improve instream morphology																							
(S) Removing hard construct.	x							x	x		x						x						
(S) Processes initialisation	x							x	x		x	x	x				x						
(S) Infill of bed sediments				x					x				x						x				
Brush mattresses																		x					
Fascines (bundles)	x									x								x					
Groyne, current deflector	x			x									x	x	x			x					
Live crib walls, slope grating	x									x				x									
Live willow racks																		x					
Log root wad																						x	x
Reed-roll revetment	x																						
(Vegetated) Rock gabions	x																						
(Vegetated) rock rip-rap	x	x				x	x											x					
(S) Restoring pools-riffles				x					x			x	x		x		x		x				x
Block ramps/Racks	x									x													
Ground ramps	x	x										x							x				
Sills	x								x														
Techniques to re-establish and to integrate flood plains																							
(S) Flood plain re-establishm.											x	x				x	x			x	x		
(S) Riparian forest	x												x	x	x	x				x		?	?
Grass, legumes, and sod										x													
Perennial herbaceous plants			x											x			x						
Live stakes	x																						
Techniques to improve continuity																							
(S) Removal of migr. barriers		x		x					x		x		x						x	x	x		
(S) Daylighting of streams			x					x											x				

Due to the close relationship between morphology and connectivity, measures to improve one type of connectivity lead to improvements in others. Measures targeting longitudinal morphology especially in many cases influence both lateral and vertical connectivity. The different aspects of connectivity cannot, theerfore, be completely separated. In the following 'stream morphology' shall be emphasised.

In order not to neglect connectivity aspects, the chapter is structured as follows:

- *Techniques to improve instream morphology* - including measures enhancing vertical connectivity with the streambed and lateral connectivity within the bank full lines of a stream channel
- *Techniques to re-establish and to integrate flood plains* and its connection to the water course – lateral connectivity beyond the bank full lines of the stream channel
- *Techniques to improve stream continuity* – representing longitudinal connectivity

5.2.1 Techniques to improve instream morphology

Changes of adjacent land uses frequently trigger 'corrections' to the stream alignment. Canalisation results in a shorter stream length and increases flow generated shear stress, hence amplifying streambed erosion. Because of their mutual interdependence, stream development, e.g. river course management, longitudinal and cross section profile, and streambed structure, must be considered together. Prior to introducing any changes in alignment, reference conditions of the river state and evolution should be taken into account (cf. Patt 1998). Nearly half (48 %) of the case studies had restored the stream alignment, either to its historical form, or according to the channel type (Figure 16).

The most common strategies used in the case studies to improve instream morphology included the removal or replacement of hard construction, initiation of more natural hydromorphological processes and the rehabilitation of a diverse habitat structure. All three groups of measures overlap and build upon each other. Almost half (48 %) of the case studies reported to have removed hard bed lining (e.g. Alterbachsystem, Emscher, Isar, Leine, Quaggy; Figure 16). Soft techniques, also called "soft engineering", "biological" or "soil-bioengineering" techniques were used in about four out of five case studies (Figure 16). Soft techniques are especially valuable in situations where spatial and other limitations do not allow the restoration of more natural river forms and functions of the water. Beside ecological improvements, these techniques are particularly valuable in terms of the aesthetical enhancement of waters. However, it must be taken into account that soft techniques, too, cannot be seen as an ecologically sound alternative to more natural states of waters. Their application in terms of ecological rehabilitation must, therefore, be understood as limited to situations where denaturalised river corridors are to be improved while perpetuating physical constraints.

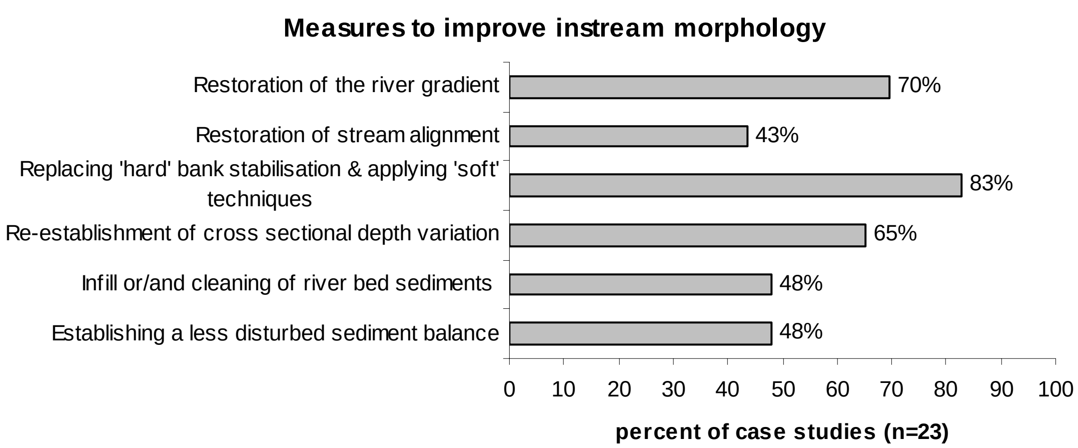


Figure 16: Measures to improve instream morphology

In canalised streams hydromorphological processes are severely restricted. Therefore, measures that provide the potential for the self-adjustment of streams to reshape bed and banks are important. Techniques providing for point protection on the one hand can be used as efficient methods to selectively protect river bed and banks (e.g. to protect adjacent power supply lines, Skerne). On the other hand, these measures can be applied to initiate habitat shaping hydromorphological processes by using the natural power of flowing water. Techniques found in the case studies are *groynes and current deflectors*, *live willow racks*, *brush mattresses and branch layers*, *fascines*, *live (log) crib walls*, and *log root wad with bolder revetment*.

In urban areas, where space for natural bed development is restricted and major influencing parameters are disturbed, a full restoration of hydromorphological processes may be exceptional. Soft techniques can be used to provide parallel flow for channel refinement in areas where space demand has led to the narrowing and deepening of the channel and hard bank stabilisation has been used along the water's edge. Soil-bioengineering structures often can have a bearing and retaining strength similar to "hard engineering" and conventional pilings, but they add vegetation improving aesthetic and wildlife value, while sustaining prior functions. In the case studies diverse forms of *rock riprap*, partly with vegetation and *reed-roll revetment* have been applied. *Tiered wall or pilings with bench plantings*, *vegetated slope grid* and *branch packing* are further measures to guide flow and secure banks, but have not been explicitly mentioned in the case studis.

In some case studies "controlled hydromorphological processes" were established. The Isar scheme provided both natural processes and the required security along the riverbanks. The compromise was reached through a combination of punctual underground scours control techniques, securing in case of erosion, and initiation of hydromorphological processes. In terms of the improvement of vertical processes (vertical connectivity) in 48 % of the case studies sediment cleaning or replacement resp. infill took place (Figure 16). This included the placement of cobble and gravel banks to support later self-sustaining hydromorphological processes.

A polymorphic material structure in combination with longitudinal and transverse depth variations offers the patchwork of habitats necessary to supply aquatic species with space for living and reproduction. Transverse structures that cross the streambed can partly re-establish the functions of macrostructures such as riffles that have often been removed through pastmanagement in many urban streams. Sills, diverse types of ground ramps, block ramps and racks create stream features that help to improve habitat diversity for macro invertebrates and small fish. They increase turbulence that aerates streams, and raise dissolved oxygen levels which are critical for fish survival. Furthermore, pools and riffles stabilise the streambed against erosion by naturally reducing the riverbed gradient. Transverse structures are also used for replacement of migration barriers such as weirs. The restoration of pool riffle structures was mentioned by over 70 % of the investigated rehabilitation schemes (Náhon, Wandse, Quaggy, others; Figure 16). Goals to improve ecological continuity, as well as sediment balance and flood protection can overlap.

Closely related to the hydrodynamics of waters, sediment balance is an important hydromorphological factor. About every other case study mentioned measures to establish a more natural sediment balance (Figure 16). The sediment balance of waters is closely related to hydrodynamics and hydromorphology but also overlaps with aspects of water quality. Improvement of sediment balance may be defined through consideration of historical channel layout and data on flow dynamics. Resulting stream alignment measures (e.g. 'stream course modifications to re-establish a more natural sediment balance', etc.) have been mentioned by the case study partners. Hydrological and hydromorphological modelling has been used to support the development of sustainable solutions (Skerne, Náhon). They allow the design of permanent measures to improve instream morphological conditions (Chapter 5.2) as basis for a more natural sediment balance.

Techniques to prevent erosion already mentioned in Chapter 5.3 contribute to an improved sediment balance. This includes sediment traps, such as *sediment ponds* (Fosso della Bella Monaca, Don, Mud Creek), *check dams for sediment control* (Alterbachsystem, La Chaudanne), and *management of construction sites* (e.g. construction traffic, temporary runoff diversions and chutes). Some of the techniques used for hydrological improvements combine to a different fraction targets of sediment control and hydrological improvements. Among those techniques *wet ponds with extended detention* were most frequently named in the analysed schemes.

5.2.2 Techniques to re-establish and to integrate flood plains

Flood plains are by definition part of any riverine ecosystem and are normally characterised by typical riparian fauna and flora. The need for lateral connectivity, therefore, particularly applies to the flood plain. About half (52 %) of the schemes applied measures targeting flood plain re-establishment and rehabilitation (Figure 17). The quality of flood plains as retention areas can be improved by enhancing the interaction of the main river with the natural inundation area such as by lowering or relocating high water dikes, as was done in 17 % of the case studies. In 57 % of the case studies (Figure 17), flood plain re-establishment was connected with widening the cross section of channel and flood plain, which was also often associated with reducing the bank slope or even the partial lowering of the flood plain itself.

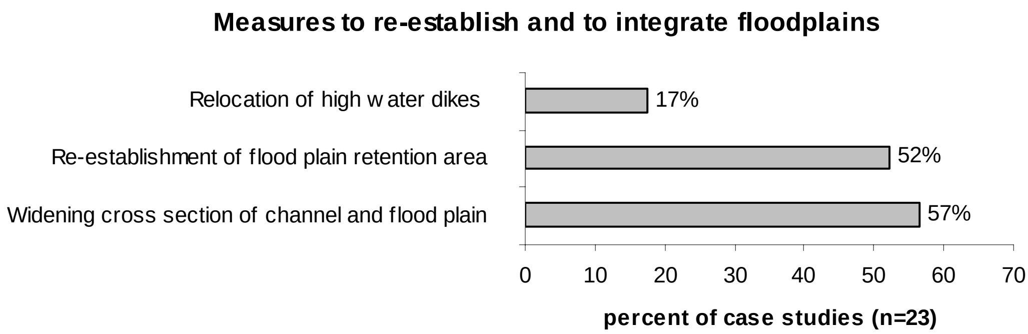


Figure 17: Measures to re-establish and to integrate flood plains

Vegetated flood plains and especially river banks play a vital role in stream hydro-morphology, water quality, water temperature and aquatic life. Therefore, re-establishment of flood plains is a frequent goal of river rehabilitation. Measures that have been applied include re-introduction of forest communities, natural regeneration, and the control of invasive exotic species.. Seeding grass and legumes, respectively seeding or planting of perennial herbaceous plants establish plant communities of riparian wildflowers, weeds, inundate grasses, and tall, herbaceous plants, but are not susceptible to serious erosion. Due to the complexity of the alluvial ecosystem, secondary alluvial forests can only be established by relying on natural succession (e.g. Leine) - maybe supported by initial plantings. Grass may only be used when a cover is absolute required in a short period of time. Live stakes, hedge brush layer and hedge layer are used to stabilise steeper slopes and establish bank vegetation including shrubs and trees.

5.2.3 Techniques to improve stream continuity

River continuity can be negatively affected through transverse structures, culverted sections and unnatural morphology. Removal or bypassing of such barriers is essential for biological migration.

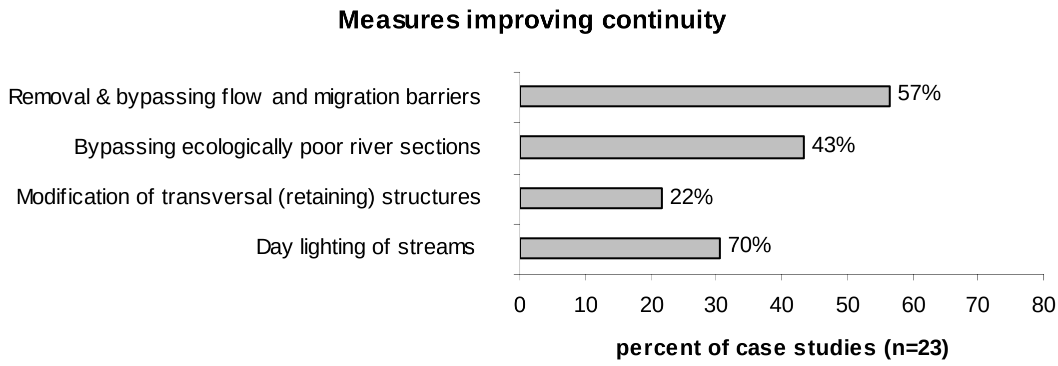


Figure 18: Measures improving continuity

Transverse structures exceeding 30 cm height, such as weirs and vertical drops, can form migration barriers to aquatic organism. Such drops were removed, replaced or bypassed in 57 % of the cases studies (Figure 18). Where mitigation barriers could not be removed they were replaced using bioengineering stabilisation techniques, transverse structures such as sills, ground or block ramps thereby allowing migration both upstream and downstream (Chapter 5.2.1), which was done in 22 % of the case studies (Figure 18). If migration barriers could not be removed, fish ladders and fish passages (Isar, Wandse, Náhon) were introduced to bypass the barriers.

Culverted sections are another barrier to the migration of aquatic organisms. Daylighting is the inevitable measure to start rehabilitation. If possible, former streambeds can be used, but also new streambeds can be formed (Woulwe, Albisrieder Dorfbach). For the establishment of a new streambed, techniques establishing and improving morphology and hydrology are applicable (chapters 5.1 and 5.2). In approximately one third of the cases daylighting was at least partly implemented (Figure 18). If no daylighting could be achieved, mitigating measures improving morphological values inside the covered channels or culverts have been considered (Emscher/Deininghauser Bach, Albisrieder Dorfbach) to mitigate at least a part of the negative effects.

Not only transverse barriers and culverted sections, but also ecologically poor sections or sections deviating from natural conditions form barriers to biological continuity. Therefore, an overall improvement of the ecological state within these sections, especially the morphological conditions, is needed. Techniques referring to stream morphology presented in other chapters apply in these cases. Where ecologically poor river sections cannot be upgraded, bypassing structures can be put in place. These have been used in 43 % of the case studies (Figure 18). In the Wandse case study a whole new stream section had to be created, bypassing a park pond. This impoundment formed a barrier due to the unnatural flow regime, physical habitat parameters and deviating chemical processes in comparison with the flowing water.

5.3 Techniques to improve water quality

Techniques for water pollution control refer to point and non-point sources. Point source pollution can be defined as pollution that enters a stream or river at a defined location (EPA 1994) and include sewage treatment plants, combined sewer overflows, sanitary sewer overflows as well as illegal dumping and illegal sewage connections. Treatment of point sources is applied in central sewage treatment plants, which then discharge into water bodies. As pointed out in Chapter 2 central plants for wastewater treatment have not been explicitly targeted by the study.

In most case studies, sewage treatment itself has not been a main objective. Nevertheless, in some schemes an upgrade of sewage treatment was implemented, such as treatment with ultraviolet radiation to reduce bacteriological loads along the Isar or the disconnection of illegal sewage inlets. Decentralised techniques such as minimising combined sewer overflows (CSO) by network separation or regulating runoff from urban surfaces have been of particular interest. For urban runoff small storage (see Chapter 5.2) and treatment facilities have been installed.

Table 12: Techniques used for improving water quality

Techniques	Alterbachsystem	Wienfluss	Woluwe	Náhon, Chrudim	La Chaudanne	La Saône, Lyon	Elbe, Hamburg Harbour	Emscher, Deininghauser Bach	Isar	Kaitzbach	Leine	Pegnitz	Wandse	Fosso della Bella Monaca	Torente Mugnone	Lower Rhine	Quaggy	Skerne	Albisrieder Dorfbach	Don, Chester Springs Marsh	Mud Creek	Anacostia, Kingman Lake	White Clay Creek
(S) CSO source control			?		x			?	x										x			x	x
(S) Comb. sewage storage														x								x	x
(S) Avoiding siltation	?			x														x			x		
(S) Construction managem.																			x			x	x
Oil/ Grit separators																			x			x	x
Grassy veget. filter strips																			x			x	x
Grassed swales																						x	x
Sand and peat-sand filters					x													x				x	x
Temp. runoff diversions																			x				x
Silt fence, trapping devices																						x	x
Sediment basins														x							x	x	
Constructed wetlands														x								x	x
Bioretention																						x	x
Hydroseeding																						x	x

Combined sewer overflows are another cause of point source pollution. Combined sewers carry sewage and storm water runoff during rainfall events while sewage treatment plants are designed with a limited capacity. Thus, during rainfall events combined sewer overflows (CSO) discharge untreated sewage mixed with storm water into local waters. *Source control of combined sewage overflows* and the *storage of combined sewage* reduce spills from CSOs. Source control combines decentralised measures and includes first of all separation of storm water runoff and sewage. This took place in about one third of the case studies (e.g. La Chaudanne, Albisrieder Dorfbach). It also includes control of illicit connections, street sweeping, catch basin cleaning, and storm water management measures which reduce or delay the volume of runoff entering the system. Measures to conserve water used in households will also reduce loads on treatment plants. Storage of combined sewage was mentioned by only 3 case studies, whereas at the Fosso della Bella Monaca combined sewer storage was combined with a wetland treatment system to clean the combined sewage. Only a few of the case studies had to deal with illegal sewage connections (Fosso della Bella Monaca).

Non-point source pollution occurs when polluted surface and subsurface runoff enters water bodies independently from provided pathways. The most important urban sources of non-point pollution are sealed surfaces (accumulation of dust and other fine grained material during dry periods) and unvegetated (polluted) soil exposed to erosion and wash out. With improving treatment technology for point source pollution in central plants, non-point source pollution becomes the primary reason that rivers, streams and lakes do not meet "fishable or swimmable" status (EPA 1998).

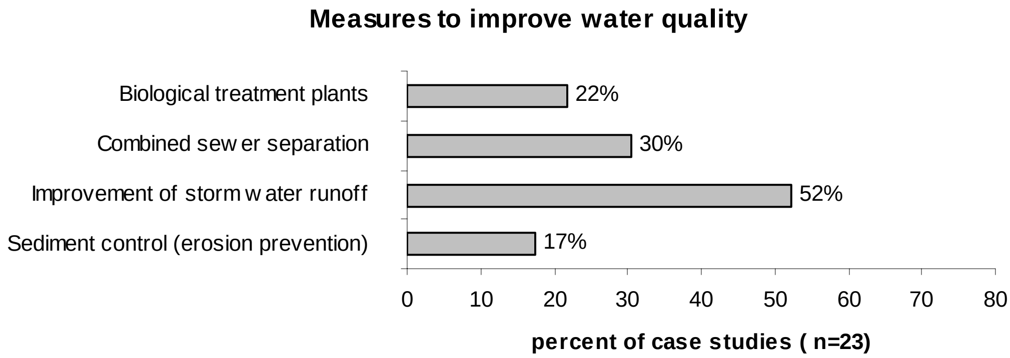


Figure 19: Measures to improve water quality

Urban runoff from streets, car parks and roofs is often the largest source of pollution for waters in urban areas. Land use planning considering water management issues and storm water management techniques can lower this pollution load by measures which, depending on the use of the urban surface, target different classes of potential surface pollution. In the case studies s*and filters and peat-sand filters*, o*il and grit separators*, g*rassy vegetative filter strips* and *grassed swales)* for road runoff have been used to trap or remove related surface pollutants. Those measures of storm water treatment were applied to differing extents in about half of all the case studies (Figure 19). Two other options with relation to both, water quality improvement and hydrological mitigation of urban runoff are *constructed wetlands*, and *bioretention*.

Silt related problems often result from increased erosion in the catchment. Therefore, measures targeting *siltation* in waters such as sediment removal or sediment exchange (Náhon) should be preceded or accompanied by measures reducing the erosion of fine material in the catchment. Depending on the sediment source, temporary and permanent measures can be taken, though temporary measures can also be used to establish permanent solutions. The latter are used to establish vegetation to reduce erosion as source of fine sediments (e.g. silt). They include *hydroseeding and chemical stabilisation*, *silt fence and trapping devices*, *sediment basins* as well as *runoff diversions and chutes* such as *gutters, drains, dikes, berms, swales, and graded pavement*. Permanent measures target river courses, where natural hydromorphological processes are to be re-established (chapter 5.2). In addition, riparian forests can play an important role as natural sediment trap for surface water before it enters the water body. For this and other reasons existing riparian vegetation is worth maintaining. Diverse measures to prevent erosion as a siltation source were applied in about 17 % of the case studies (Figure 19).

5.4 Techniques to improve biodiversity

Protection and rehabilitation of biodiversity in riverine ecosystems is a goal of the Water Framework Directive. Hydromorphological as well as chemical and physiochemical elements influence habitat quality and, therefore, the composition and abundance of aquatic, as well as riparian, flora and fauna communities. For this reason, techniques and strategies presented in Chapters 5.1 to 5.3 are also important for biodiversity issues. Techniques presented in this chapter are more directly aimed at benefitting flora and fauna. This includes techniques to provide for cover, food, nesting and spawning sites, and shelter for fish, amphibians and other wildlife. Aquatic and riparian habitats are connected (lateral connectivity), thus habitat protection and improvement refers to in-stream conditions as well as to riparian habitat.

Table 13: Techniques used for improving aquatic and riparian flora and fauna

Techniques	**A**lterbachsystem	**W**ienfluss	**W**oluwe	**N**áhon, Chrudim	**L**a Chaudanne	**L**a Saône, Lyon	**E**lbe, Hamburg Harbour	**E**mscher, Deininghauser Bach	**I**sar	**K**aitzbach	**L**eine	**P**egnitz	**W**andse	**F**osso della Bella Monaca	**T**orente Mugnone	**L**ower Rhine	**Q**uaggy	**S**kerne	**A**lbisrieder Dorfbach	**D**on, Chester Springs Marsh	**M**ud Creek	**A**nacostia, Kingman Lake	**W**hite Clay Creek
Fish ladders, fish passages				x					x		x												
Boulder clusters	x																					x	
Lunker structures																						x	
Restocking fish fauna				x									x					x					
Removal of invasive species													x							x	x		
(S) Enhancement in harbours							x																

To support aquatic fauna, efforts were taken to re-establish spawning grounds, overhead cover, detritus traps, shade and scour pools and shelters. Techniques found in the case studies included *boulder clusters* (Alterbachsystem, Anacostia) and *lunker structures* (Anacostia). In the Elbe case study, ecological *enhancement of a harbour* area was carried out. Rehabilitation measures were severely limited due to the existing uses of theharbour. Special techniques have been developed , such as floating pontoons and techniques to enhance sheet pile and quay walls, to provide cover and resting areas. In addition, the establishment of biological continuity through removal of migration barriers or the establishment of *fish ladders and fish passages* contribute to the improvement of habitat quality (chapter 5.3). In some schemes *re-stocking* with endangered and other species has been implemented. In one scheme bird breeding boxes, breeding walls, and gabions with breeding pipes have been employed to restore avifauna (Wienfluss).

Vegetation is a key component of in-stream wildlife habitat. Leaf litter and woody debris input from riparian vegetation is part of the food chain. Submerged and emergent aquatic vegetation functions as microhabitat for fish. Furthermore, the nutrient uptake of emergent plants improves water quality. The restoration of riparian vegetation was one of the most frequent measures used for rehabilitation of urban rivers being used in 87% of the case studies (Figure 20). Measures to restore aquatic vegetation were mentioned by 52 % of the case studies.

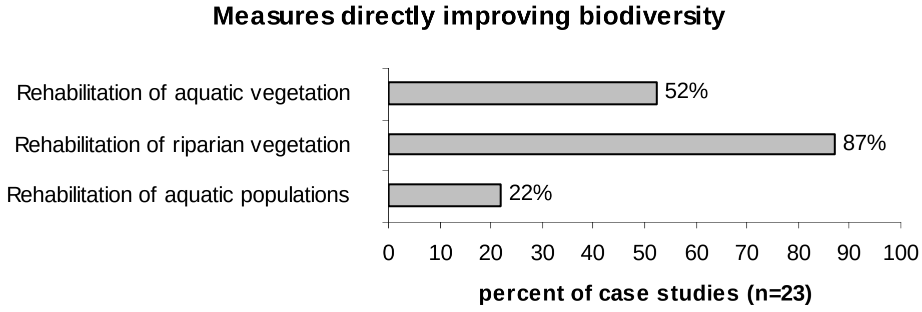


Figure 20: Measures directly improving biodiversity

About half of the schemes named '"initial planting for regeneration" or "preparing for self-colonisation" as techniques (Chapter 5.3). The control invasive species (e.g. non-native herbaceous species) played only a marginal role (Wandse, Chester Springs Marsh). In dense urban settings (e.g. Pegnitz) it was found to be advantageous to plant semi-mature nursery trees to avoid the risk of plant losses due to intensive recreational impacts.

5.5 Techniques to improve features of public health and safety

The enhancement of urban rivers brings social responsibilities. Problems that need to be addressed are public health and safety concerns resulting from flooding and recreational use of the water body and the river corridor. Case studies have been analysed with regard to aspects of public health and safety incorporated into the rehabilitation schemes and thus into techniques applied onsite. Aspects of flood control, accident and crime prevention and provision for public health and hygiene, as for instance good water quality, have been identified.

In general, two different approaches have been taken to incorporate safety and health features into rehabilitation techniques. The first one uses preventive measures targeting the causes of public health and safety problems. Measures to rehabilitate the flow regime, to reduce peak flow and thus decreasing the possibility of hazardous floods are one example. Lowering steep banks onsite, to decrease the risk of falling in and drowning is another one. The second approach uses corrective measures, which target the mitigation and management of the existing risk for public health and safety. These measures alleviate the current situation. The implementation of these corrective measures affects the situation immediately, while preventive measures are more to be seen as a long term and as a basin wide investment as proposed by the WFD. Furthermore, in urban areas, existing and competing land uses limit the possibility for cause-oriented, preventive measures. In most case studies both approaches have been combined for an effective health and safety care in urban river rehabilitation.

Flooding is one of the most frequent issues causing health and safety problems in urban areas. The goal to reduce the risk of flooding has initiated some of the analysed rehabilitation schemes and was considered at least to some degree in almost all case studies. Predefined flood frequencies, up to which flood control should take place, provide a base for all measures. These have been defined from 30-year (Alterbachsystem) up to 350-year storm water events (Mud Creek), depending on local urban density, land use or existing regulations. Along the Wienfluss downstream protection within the city area has been designed for a 1.000-year flood event and the retention system's spillway upstream of the city for a 5.000-year flood event.

Table 14: Techniques incorporating features to improve public health and safety

Techniques	**A**lterbachsystem	**W**ienfluss	**W**oluwe	**N**áhon, Chrudim	**L**a Chaudanne	**L**a Saône, Lyon	**E**lbe, Hamburg Harbour	**E**mscher, Deininghauser Bach	**I**sar	**K**aitzbach	**L**eine	**P**egnitz	**W**andse	**F**osso della Bella Monaca	**T**orente Mugnone	**L**ower Rhine	**Q**uaggy	**S**kerne	**A**lbisrieder Dorfbach	**D**on, Chester Springs Marsh	**M**ud Creek	**A**nacostia, Kingman Lake	**W**hite Clay Creek
(S) Flood proofing structures			x				x								x	x	x	x	x				
(S) Flood Plain retention									x		x	x				x	x			x	x		
(S) Dikes, levees, floodwalls									x		x					x							
(S) Emergency management												x											
(S) Safe bank design									x		x	x					x	x					
(S) Underground scour control	x								x														
(S) Accident Prevention			x				x							x	x		x	x	x				

Protection of human beings from mortality, injury and diseases caused by floods within densely populated urban environments usually had a higher priority than environmental, recreational or aesthetic aspects. During the last century flooding was controlled through canalisation and the construction of levies, resulting in ecological degradation. Nowadays ecological understanding promotes measures that combine safety with ecological aspects. Hard constructions are being replaced by soft techniques and/or by more generous stream channels and flood way designs. Preventative measures reducing peak flows are taken to solve a part of the problem at its source. Measures, such as additional flood storage capacity through channel widening and re-established *flood plain retention,* belong in this category (Chapter 5.2).

Corrective measures identified in case studies to prevent flood damage, as well as to reduce harm to human beings, included constructional *flood proofing of structures* in 30 % of the case studies, *emergency management* (mobile flood protection, emergency access and flood warning systems) in one case study (4 %), the use of *dikes, levees and floodwalls* but also *safe bank design* (lowering or terracing of banks) and underground scour control (Figure 21).

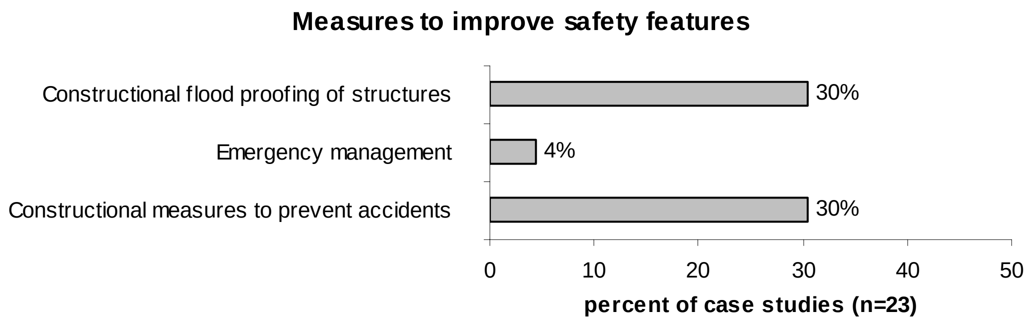


Figure 21: Measures to improve safety features

Techniques for *accident prevention* have been implemented in about 30 % of the case studies (Figure 21). Measures to protect public health and to reduce the risk of accidents resulting from the proximity to flowing or standing water have to be considered since with the rehabilitation of urban river corridors, including the water body itself, makes then increasingly attractive for recreational uses.

To reduce accidents by drowning, several measures have been used. In case studies, where recreational uses play a major role, preventive measures very often included a *safe bank design*, reducing the slope of banks, terracing banks etc. to avoid sudden inundation. Where channels could not be reshaped, corrective measures such as escape ladders (Woluwe) have been supplied. In some cases along steep walls along rivers, railings have been installed (Wienfluss). Along some sections of the Isar, bollards separate pathways and the water. At inlets to culverted sections, fences or trash racks have been installed (Albisrieder Dorfbach). Public education and information about the risk of using flowing water for recreation can support these technical measures.

Issues of public health can also be connected to issues of water quality. Thus, measures that improve water quality will help to reduce public health risks caused by human contact with water (Chapter 5.1). The European Bathing Water Directive (BWD 1976) sets European standards for the water quality of recreational waters. In the case of the Isar, intensive recreational use of the river already takes place. Now secondary treatment with ultraviolet light has been established in all plants upstream of Munich to ensure that the quality requirements of the directive are met.

Another danger to public health is the trash and litter either transported by the river itself or left by human beings. For floating litter trash racks and screens in tributary streams have been used in the case studies to remedy problems (Isar, Rom). Litter bins can reduce trash problems caused by extensive recreational use of the river corridor, but may become hazardous, if they are not regularly emptied.

Degraded river sites are often areas with increased crime. A decrease in the crime rate in some cases was connected to urban and social enhancements induced by river rehabilitation schemes. There is no quantitative data on this but experiences on sites suggest that this may be the case. Many measures to improve security or public perception of safety along river corridors follow the design concept of 'Crime Prevention through Environmental Design'. This included appropriate night time lightning, appropriate visibility through transparent vegetation structures (Quaggy, Skerne, Woluwe) and improved accessibility (Don River). Accessibility has been found to play a major role, not only to reach the river corridor and the water, but also to leave the river corridor in an emergency or in case of flooding.

6 Impacts of river rehabilitation projects

Considerable planning effort and financial spending go towards achieving urban water rehabilitation and the related goals of schemes (Chapter 3 and Chapter 4). Any scheme influences both the urban waters and the surrounding area in a complex way that often extends beyond the predefined targets. Therefore it is of special interest to analyse the impacts of these schemes. At the same time this is also a considerable challenge, since so far almost no consistent set of indicators and evaluation methods exists that can be applied in urban settings (Chapter 9) and cover comprehensively the particular targets of urban river rehabilitation (Chapter 3). This issue appears even more complicated if seen against the background of various monitoring systems and individual perception patterns in different European cultures.

Urban areas are characterised by a narrow grid of diverse land uses. This is also true for areas surrounding urban waters. Thus water bodies themselves, as well as their surroundings, are part of the more or less intensely used urban areas but which also have the potential to fulfil various ecological and societal functions. Particularly in urban areas, the components of the 'sustainability triangle', consisting of ecological, social and economic aspects, are closest. It is not at least for this reason that urban river rehabilitation schemes often contain a strong component of urban upgrading, enabling or improving societal functions along and around the water courses.

For this reason many urban rehabilitation projects are characterised by a multitude of different targets for rehabilitation and enhancement (Chapter 3). In many case studies areas adjacent to the river rehabilitation sites have been included into the schemes, indicating the importance of social and economic aspects. In consequence, even for rehabilitation schemes primarily aiming at improving ecological functions, ecological monitoring alone will not cover all the relevant areas of interest. Monitoring and assessment of urban rehabilitation schemes, therefore, needs to consider also social and economic factors.

Based on the standardised data enquiry, this study attempts to conduct an impact assessment of the twenty-three case studies of urban river rehabilitation in Europe and North America. The approach is designed to compare the conditions of proposed parameters before and after the implementation for each rehabilitation scheme.

To measure the *ecological effects* of urban river rehabilitation schemes European wide defined state classes (WFD 2000) are used. On the one hand their use at the moment means a compromise, since the only recently inaugurated directive is not yet fully implemented and the available data may not be accurate. This applies especially as most schemes where begun and often even finished before the directive came into force. This official scale on the other hand is the only means to overcome incompatible national classifications and allows effects to be displayed in a comparable way. To minimise uncertainty the classification of the ecological states was carried out by local partners dealing with ecological features of the water body of concern on the basis of existing national measurements and classifications. The results that were obtained allow an overview of the ecological impacts and display trends in terms of the ecological effects of urban river rehabilitation.

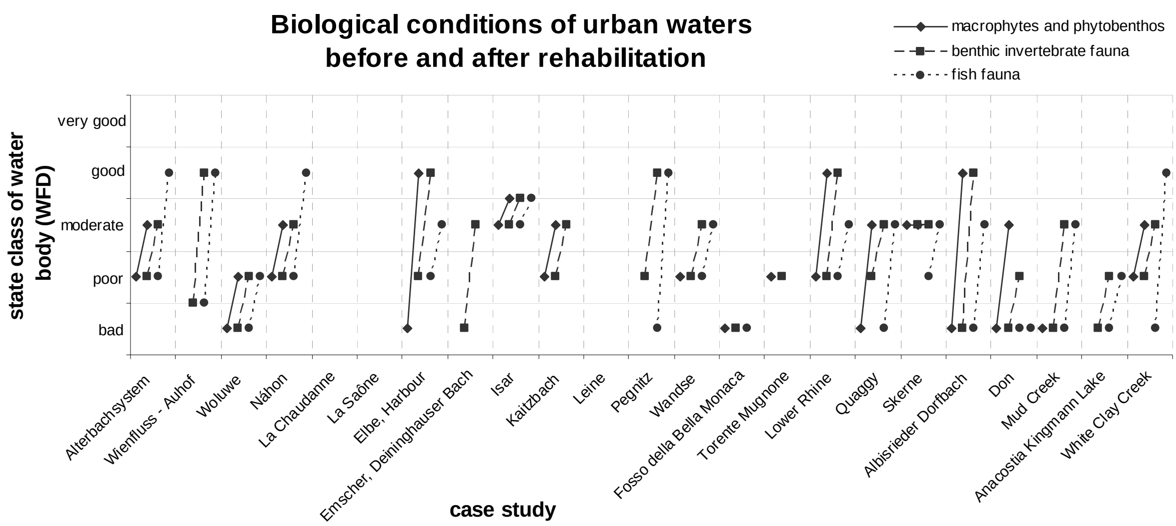
For the investigation of *social, aesthetical and economical impacts,* including public health and safety, a comprehensive set of criteria has been developed and applied. These criteria were systematically collected to cover the most relevant aspects of societal impacts referring to the interrelation of waters and urban areas. On one hand these criteria served to investigate how the issues of interest were approached by the rehabilitation projects. On the other hand a three step ordinal scale was offered to assess the condition of each parameter before and after the implementation of schemes.

In the following the ecological and societal criteria related to urban waters are used to provide a condensed characterisation of how urban river rehabilitation schemes can influence river ecology as well as the societal well being in the surrounding area. When bringing together the indicators of ecological conditions both natural and potentially artificial water bodies are considered in the same way, since the classification of natural and artificial water bodies have not yet been conducted for most water bodies. Consequently the two water bodies that, due to their genesis, are known to be artificial - Náhon (old mill race) in Chrudim (CZ) and Fosso della Bella Monaca (urban ditch) in Rome will be presented in the same scope as the others, which are more probably natural waters. When referring to the ecological conditions all waters are summarised under the characterisation 'ecological status' or 'state'. For the two artificial waters the relating classes of 'ecological potential' is meant.

6.1 Ecological impacts

Biological conditions

Following the scope set by the WFD, biological parameters are used as one indicator group to assess the ecological state of water bodies. Parameters for the hydromorphological conditions as well as the chemical and physico-chemical conditions serve as additional indicators which are relevant to the river biology. In the following, these indicators are used to characterise the impacts that rehabilitation schemes have had on the state of the urban waters. Parameters used by the Bathing Water Directive will not be presented, as large waters were found to be of minor importance. Due to this insufficient data was obtained.



* Lines indicate the change of parameters in each case study, starting left below ore above (state before) and ending right above or below (state after rehabilitation)

Figure 22: Biological conditions of urban waters before and after rehabilitation

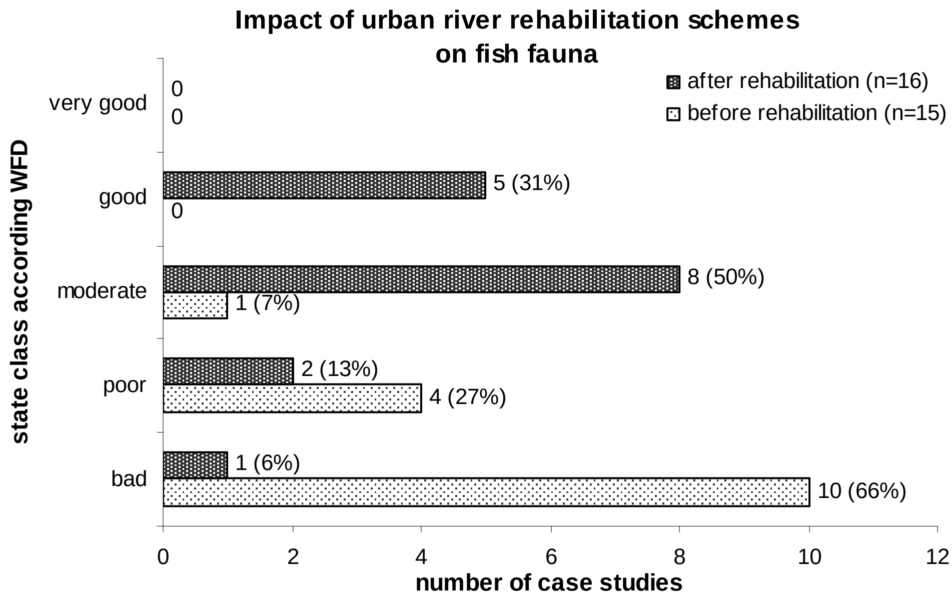


Figure 23: Impact of urban river rehabilitation schemes on fish fauna

In most case studies, biological conditions were reported to have improved by one to three classes in the rehabilitated stretch of the water (Figure 22). However, complete information could not be obtained for all case studies since often no or incomplete monitoring data were available. This applies especially to the most recent case studies (e.g. La Chaudanne, Leine, Fosso della Bella Monaca). It is worth mentioning that in many case studies all three biological indicators (Figure 22) the correlating development of all three in similar dimensions. This may indicate distortions in the transformation of results into the classification of the WFD that were discussed above. However, despite possible imprecision, the results indicate a clear trend of improvement in the case studies.

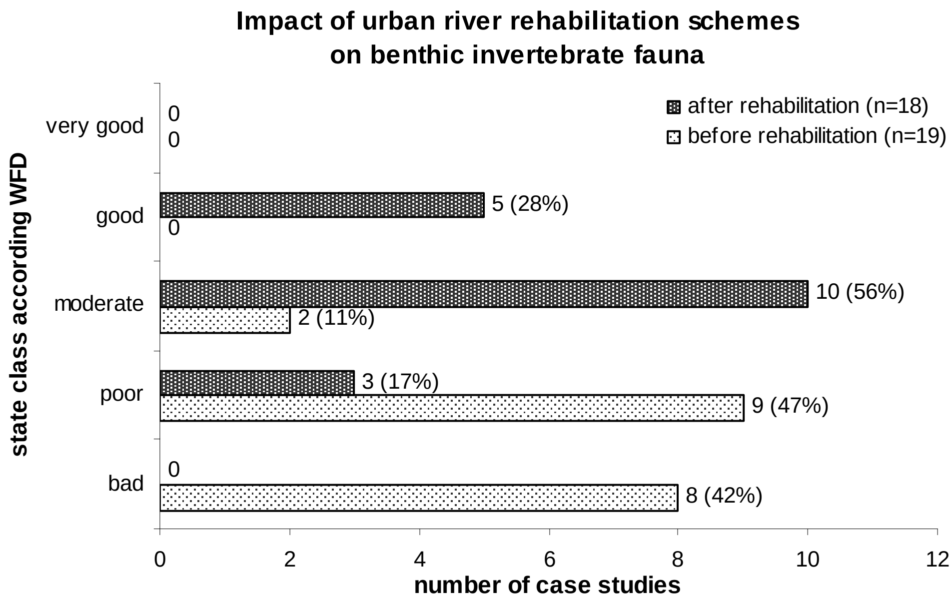


Figure 24: Impact of urban river rehabilitation schemes on benthic invertebrate fauna

Due to the size of water bodies represented by the case studies (Chapter 3) there was hardly ever any data on the indicator 'phytoplancton' and thus this is not presented. The three most mentioned bio-indicators (12-19 responding case studies) are 'fish fauna' (Figure 23), 'benthic invertebrate fauna' (Figure 24), and 'benthic macrophytes and phytobenthos' (Figure 25).

For about 90 % of the responding case studies all three bio-indicators were recorded to be in a 'bad' or 'poor' state prior to rehabilitation - fish fauna being in the worst state (63 % 'bad'). After rehabilitation 80 to 90 % of the case studies found these parameters in a 'moderate' or even 'good' state. However, while about 50 to 70 % reached 'moderate' status, only 20 to 30 % had reached the target 'good status' of the WFD. However, for the majority of schemes the directive could not yet apply as a target. For some schemes a better state may evolve in the future, since they are still under development.

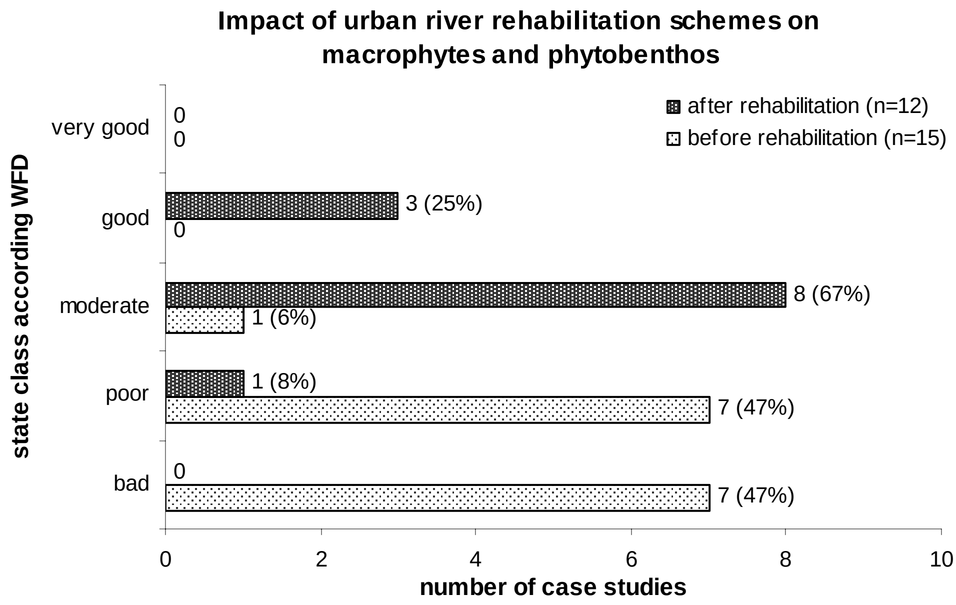


Figure 25: Impact of urban river rehabilitation schemes on benthic macrophytes and phytobenthos

Hydromorphological conditions and chemical and physico-chemical components

Indicators of 'hydromorphological conditions' and 'chemical and physico-chemical components' determine the physical framework of the habitat quality in a water body. A high percentage of the case studies provided information on the hydromorphological conditions (14 to 19 responding case studies – Figure 26). For the chemical and physico-chemical components only information on the 'general conditions' were provided (14 resp. 15 responses - Figure 30). This may reflect that hydromorphological conditions were of greater interest in the case studies. On the other hand this may underpin that measurements of the parameters "specific synthetic conditions' and 'specific non-synthetic pollutants", as defined by the WFD, were not yet covered by most applied monitoring programs.

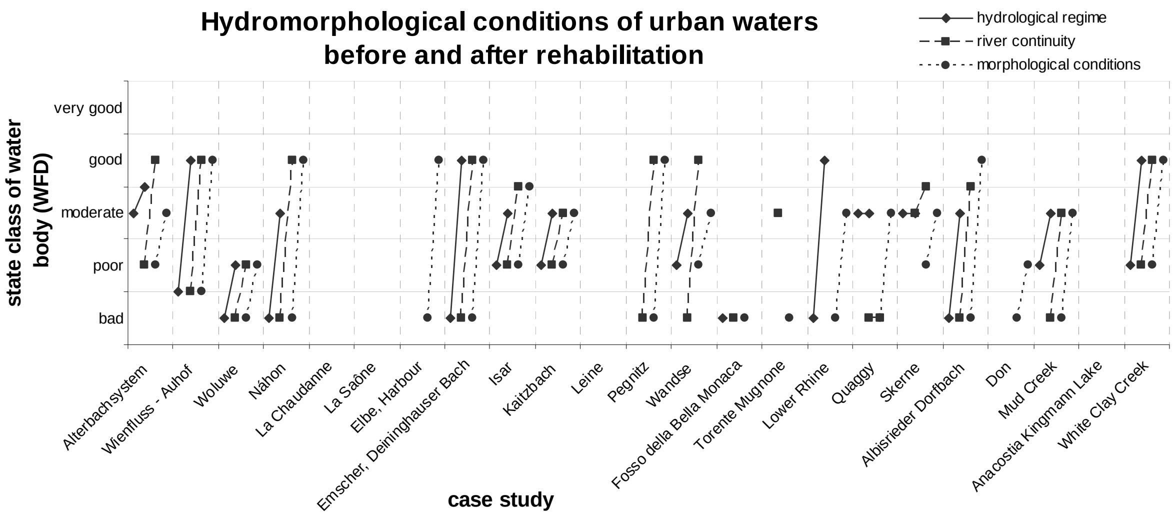


Figure 26: Hydromorphological conditions of urban waters before and after rehabilitation

Instream morphological features of water bodies were a typical target of urban rehabilitation projects. This may be seen as a response to the typically constrained situation resulting from a history of past development. In 100 % of responding case studies the morphological conditions were reported to be in ‘bad’ (68 %) or ‘poor’ (32 %) state (Figure 27).

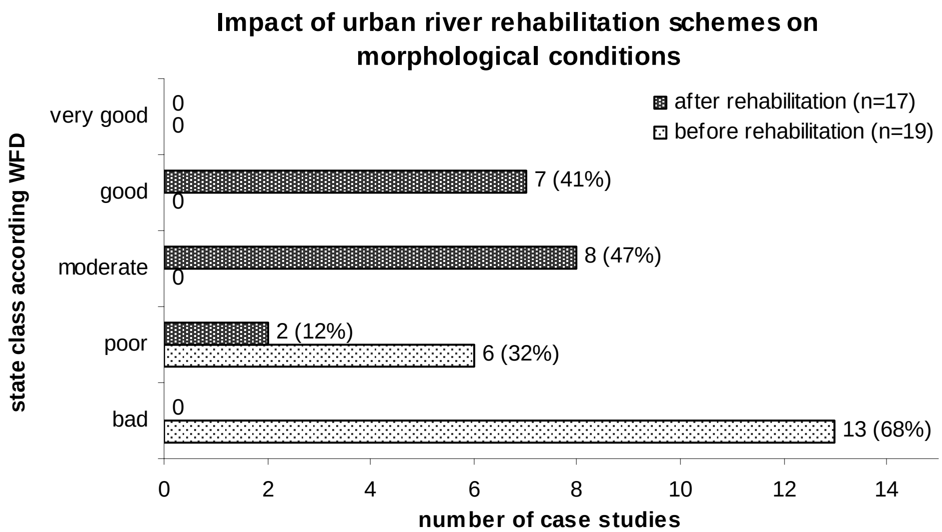


Figure 27: Impact of urban river rehabilitation schemes on morphological conditions

After rehabilitation almost half (47 %) of the responding case studies the morphological condition had achieved ‘moderate’ status and 37 % had even reached ‘good’ status. However, two of the cases only made an improvement from ‘bad’ to ‘poor’ morphological state.

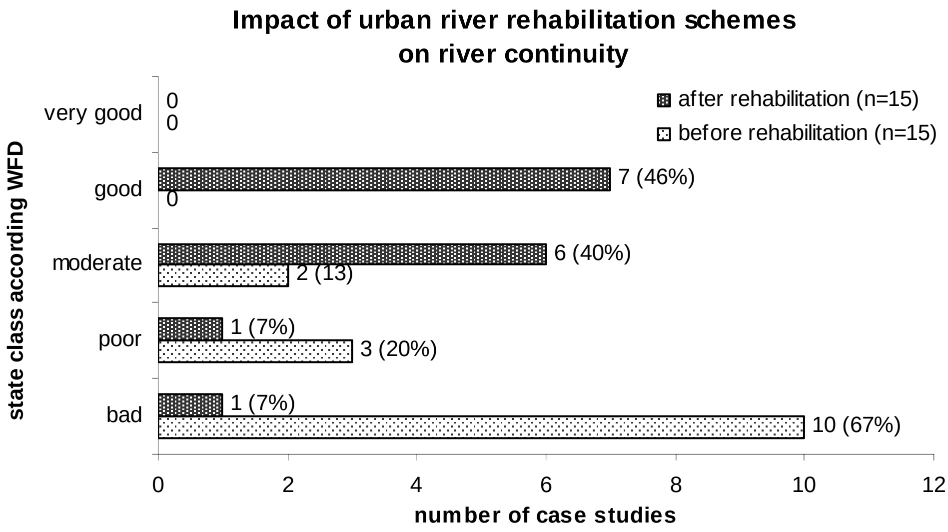


Figure 28: Impact of urban river rehabilitation schemes on river continuity

The impact on river continuity (Figure 28) only applies to the rehabilitated sections as no external measures were considered. It is thus linked to measures targeting morphological features including the improvement of cross sections. This onsite-continuity improved from predominantly 'bad' (67 % of responds) and 'poor' (20 %) to 'moderate' (40 %) and 'good' (46 %). Two case studies did not improve beyond the 'bad' resp. 'poor' state, which may be explained by their especially constrained settings.

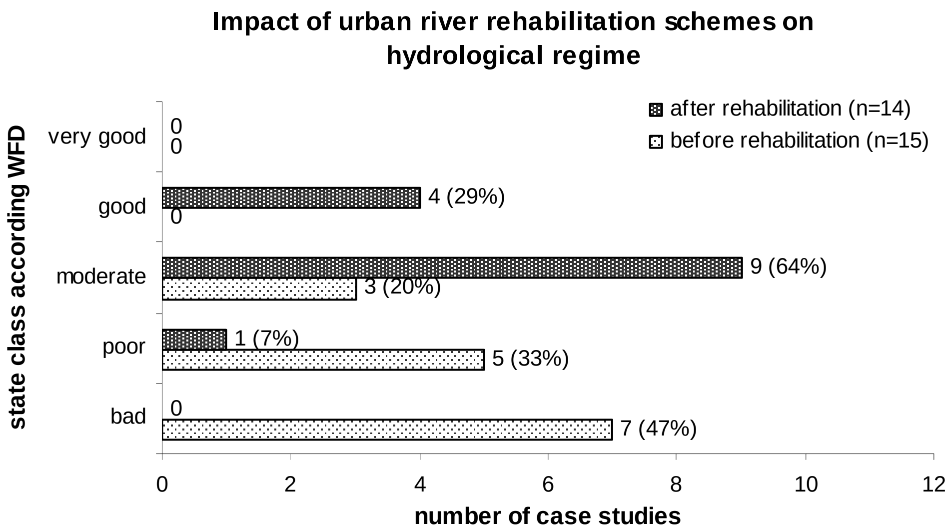


Figure 29: Impact of urban river rehabilitation schemes on hydrological regime

The hydrological regime (Figure 29) was reported to have improved from 'bad' and 'poor' status (together 80 % of responding case studies) to mostly 'moderate' status (64 %). In four cases (29 %) even a 'good' state was achieved. However, in this context it is important to mention that in most cases the hydrological regime was not a fundamental objective of the schemes (Chapter 3). It was rather indirectly affected by the rehabilitation schemes and changes mostly refer to the on-site character of the hydrological and hydraulic features e.g. as a result of changes to the cross sections to modify the duration of bank full and over bank flows and by affecting the connectivity to the groundwater. Also measures of storm water management had positive impact on the hydrological regime.

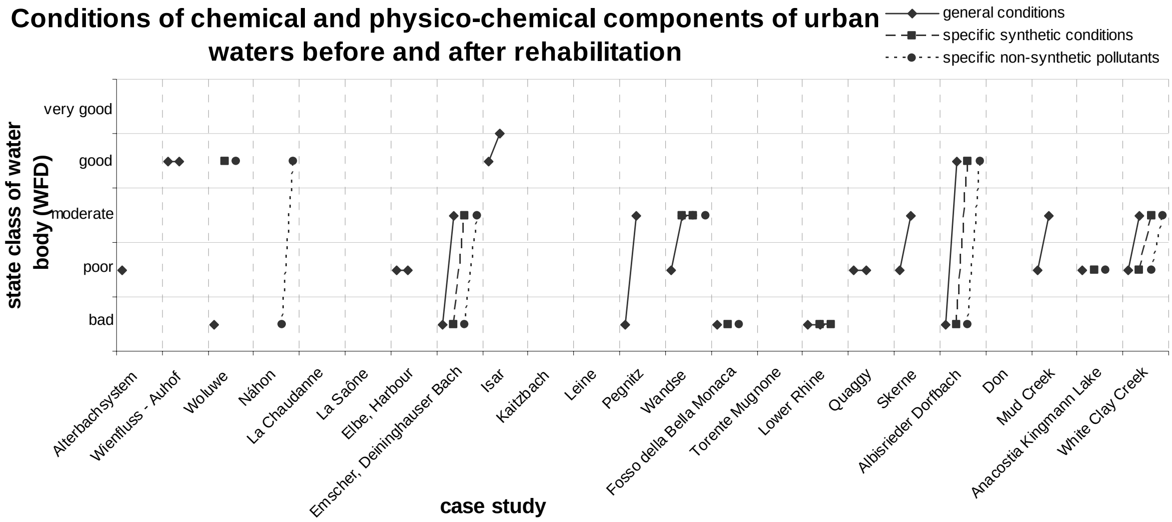


Figure 30: Conditions of chemical and physico-chemical components of urban waters before and after rehabilitation

As mentioned above, there were few responses from the case study partners in the conditions of the chemical and physico-chemical components (Figure 30). This means that the sole parameter that can be considered is 'general conditions'.

Unlike the other ecological parameters 'general conditions' of chemical and physico-chemical components have improved clearly but not as significantly (Figure 31). The majority of the responding cases had improved from 'bad' (38 %) or 'poor' (50 %) state before rehabilitation to 'moderate' (50 %) or 'good' (25 %) state after rehabilitation. Three case studies remained in 'poor' or 'bad' state. The number of responses to states after rehabilitation is considerably lower than for the state before.

The reason for this situation most probably can be seen in the circumstance that chemical and physico-chemical parameters have not been of primary interest of the considered schemes, which is also explained by the selection method (Chapter 2). However, from the information obtained it can be concluded that measures taken in the scope of mostly multi-targeted projects have also lead to some improvement of general conditions.

With regard to the analysis of ecological parameters, it must be emphasised that there were only a low number of responses. One reason for this is certainly the fact that measurements according the WFD have not been made and in some cases no extrapolation from existing measurements was possible. Another reason is to be seen in the very young age of some schemes. But it is also true that ecological effects of river rehabilitation schemes are often not sufficiently monitored, which makes it complicated to produce a consistent and representative review of the situation.

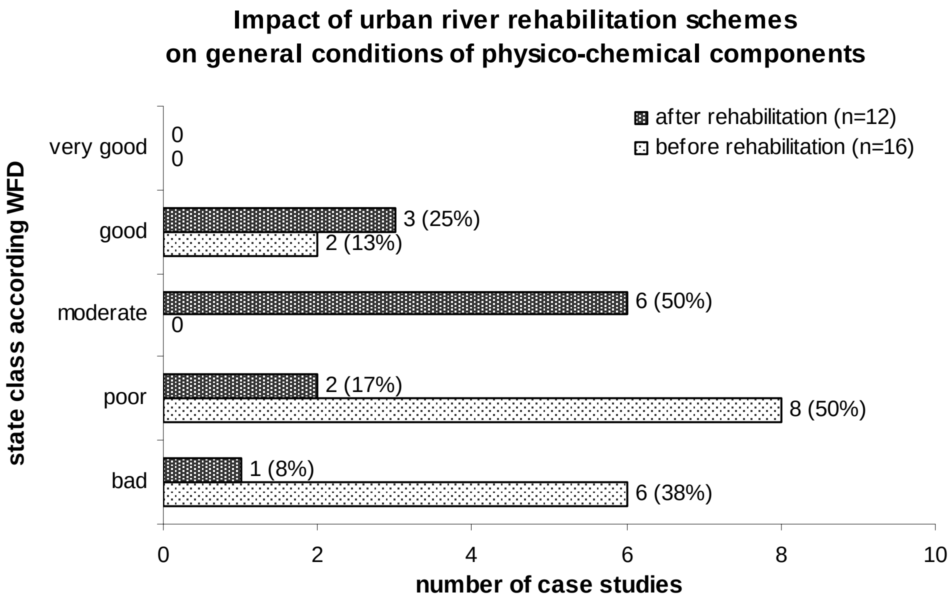


Figure 31: Impact of urban river rehabilitation schemes on general conditions of physico-chemical components

6.2 Social and aesthetic impacts

Unlike in the case of ecological impacts, societal impacts described below not only indicate change in the state of a certain parameter but also the relevance of this parameter. Thus, if nothing is stated for a given parameter in one case study this, in most cases, also means that this parameter is not relevant to the scope of the rehabilitation project.

The scale applied is a proposed 3 step ordinal scale. The case study partners were asked to estimate the specification of the parameters on the scale embracing the 'steps above average' – 'average' – 'below average' and comparing the state of each parameter in the rehabilitation area with its comparative (reference) state in the urban area.

Aspects of social and cultural infrastructure

In many rehabilitation projects an enhancement for active and passive recreation as well as educational aspects played an important role. In this context active and passive recreation uses were of priority (Figure 32, Figure 35). This once more underlines the importance of urban water courses for open space uses.

Due to the small size of most of the water courses considered, water related sports played only a minor role (only five case studies responded to this issue). However, the use of river corridors for non-water related sports and playful recreation has been considered and has improved (Figure 33, Figure 34). In both cases this is connected with on-site infrastructure improvements, establishing better site accessibility as well as a general increase in public acceptance of the sites (see below).

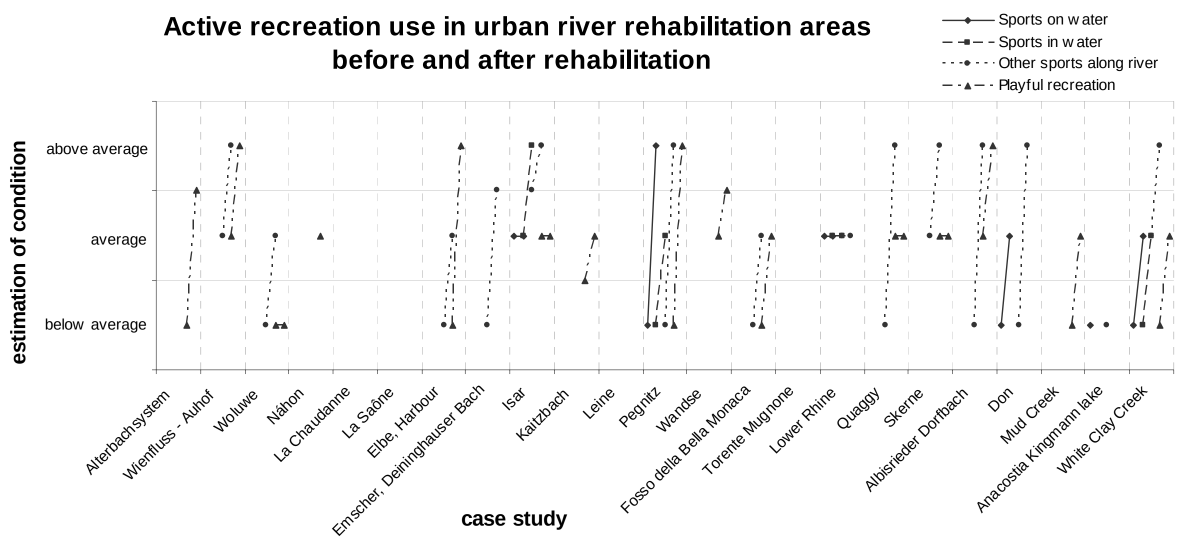


Figure 32: Active recreation uses in urban river rehabilitation areas before and after rehabilitation

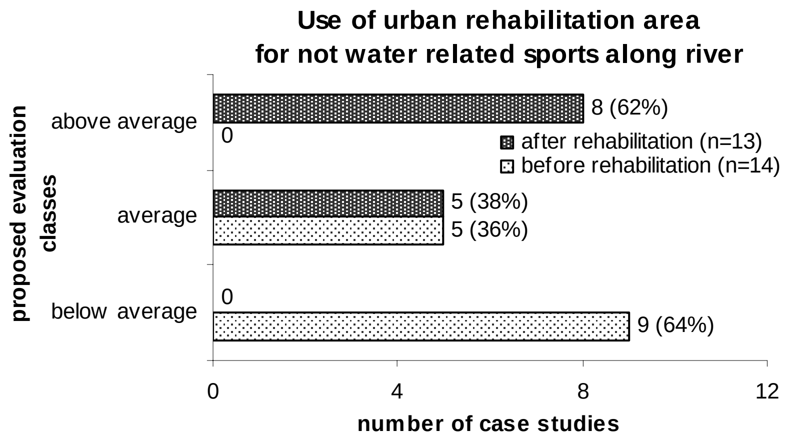


Figure 33: Use of urban river rehabilitation areas for not water related sports

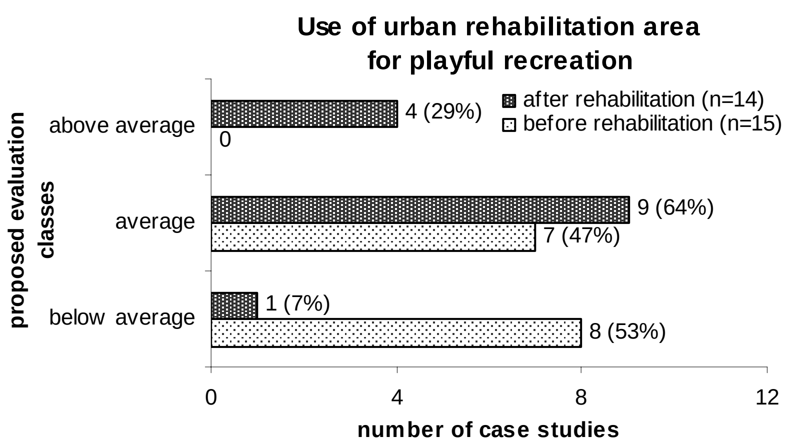


Figure 34: **Use** of urban river rehabilitation areas for playful recreation

In most case studies, passive recreation such as 'nature observation', 'picnicing' as well as 'walking and relaxation' whereas important, whereas 'fishing' played a role in about half of the case studies (Figure 35).

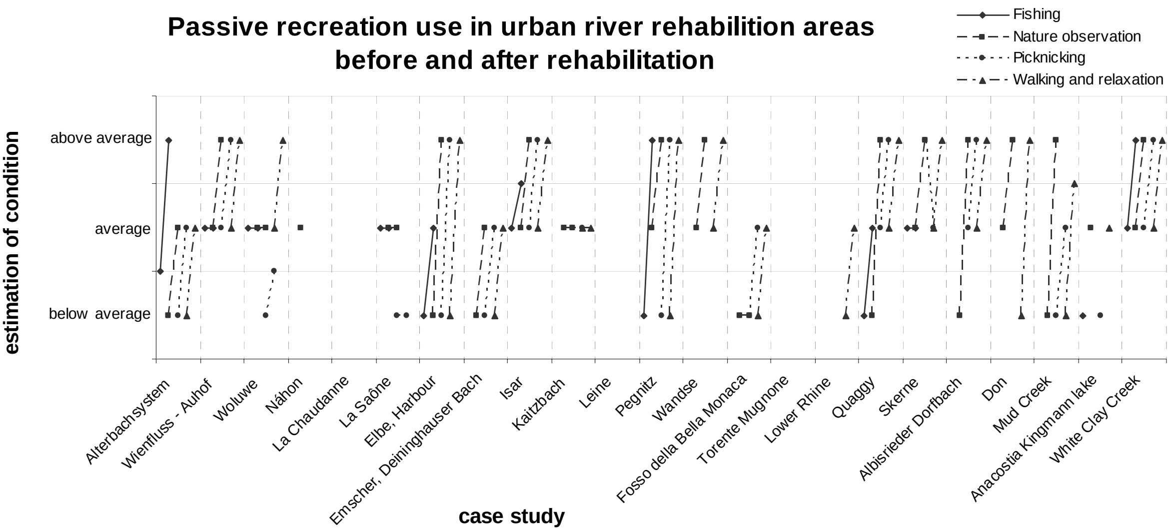


Figure 35: Passive recreation uses in urban river rehabilitation areas before and after rehabilitation

Prior to rehabilitation all three passive uses 'nature observation', 'picnicking' and 'walking and relaxation' were estimated to be 'below average' and 'average' with typical shares of about 40 to 60 %. After rehabilitation passive uses of the area were rated mostly 'above average' with about 30 to 40 % rated as 'average'.

Of the cultural, educational and commercial parameters predominantly the historical and environmental education is the most relevant (Figure 36).

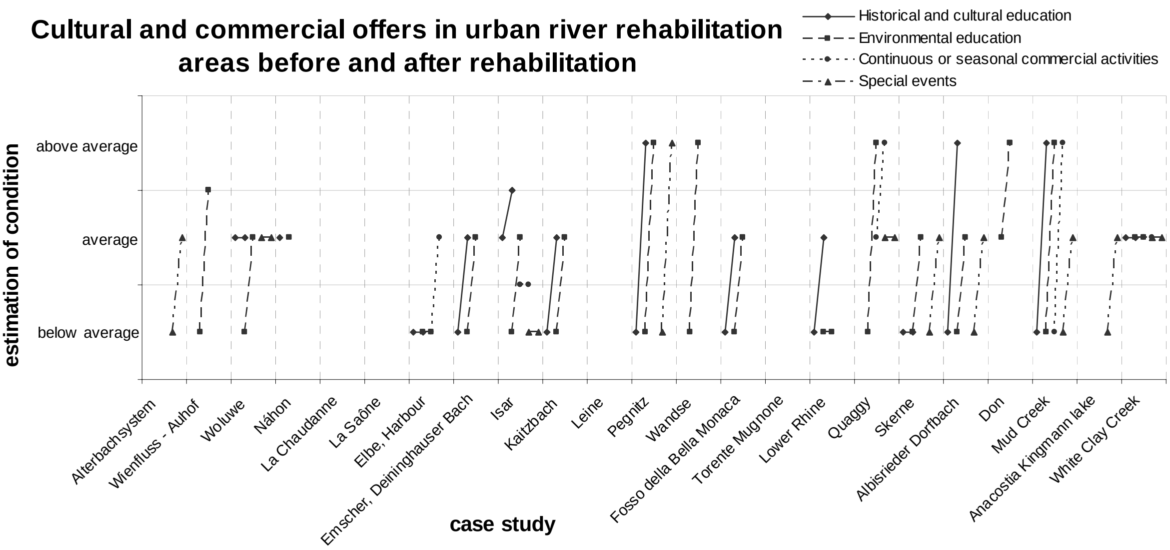


Figure 36: Educational, cultural and commercial offers before and after rehabilitation

Both the environmental and cultural education aspects seem to have been underrepresented before the rehabilitation. However, in many cases these aspects and their use improved after rehabilitation at least from 'below average' to 'average', and in some cases to 'above average' (Figure 37). The same is true of 'historical and cultural education' (Figure 38).

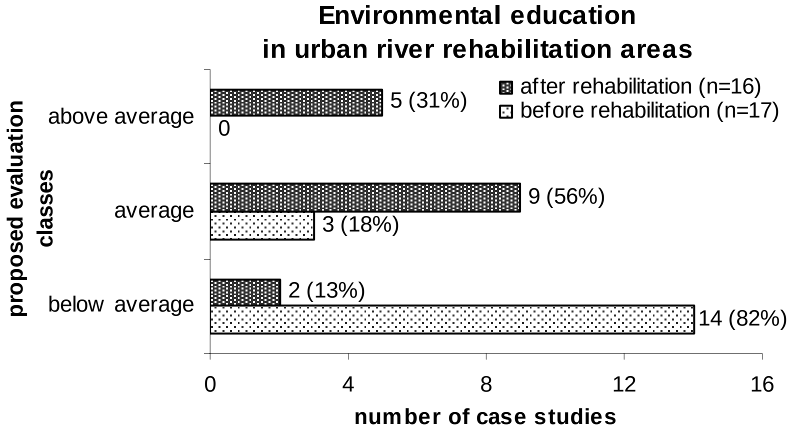


Figure 37: Environmental education in urban river rehabilitation areas

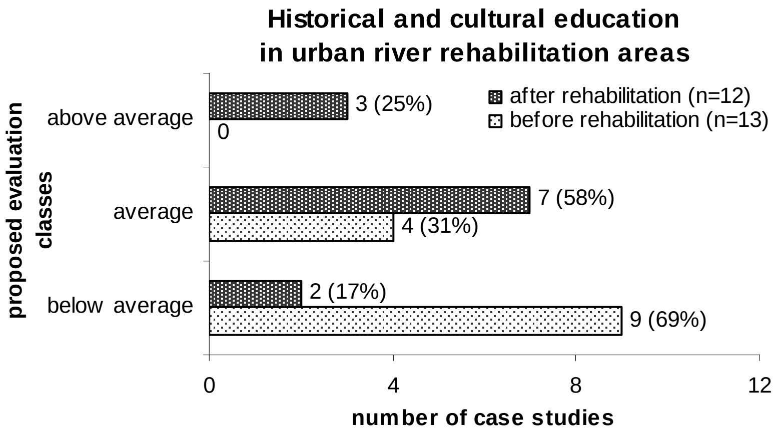


Figure 38: Historical and cultural education in urban river rehabilitation areas

Aspects of social and aesthetic perception and experience of riverscape

Despite the fact that ecological improvement was the primary criteria for the selection of the case studies, about 60 % of the rehabilitation schemes that were considered contained components that improved the aesthetics of the urban water and its surroundings.

Two of the parameters shown in Figure 39 represent the aesthetic impact achieved . The first parameter, 'focal points' are important landscape elements attracting the visitor's attention and guiding visitors through the area. In many case studies, new elements were introduced into the river corridor or existing ones were enhanced to become focal points, supported by the wide views linked to the open character of water bodies. In some cases the water body itself even became such a focal point. Thus the presence of focal points was reported to have increased in most schemes by one or even two steps (Figure 40). Whereas prior to rehabilitation the majority of responses named 'average' and 'below average' states, after rehabilitation 60 % had reached 'above average' and none remained below 'average'.

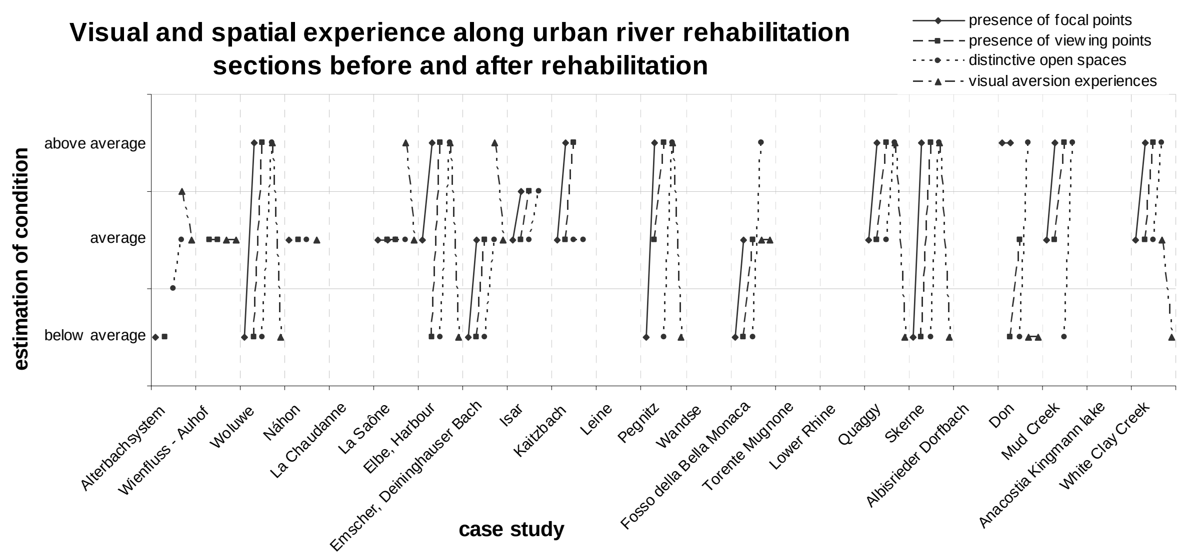


Figure 39: Visual and spatial experience along urban river rehabilitation sections before and after rehabilitation

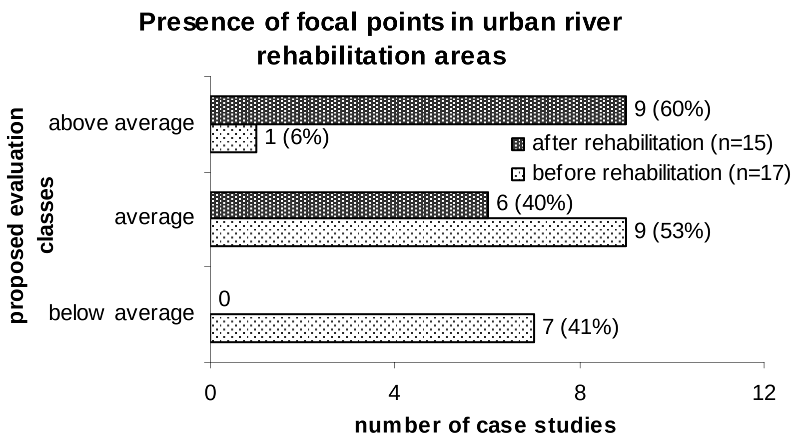


Figure 40: Presence of focal points in urban river rehabilitation areas

The second parameter, 'visual aversion experiences' (Figure 41), in seven case studies was reported to be 'above average' indicating that urban water courses often have been neglected prior to rehabilitation. This is also underpinned by the experience that river rehabilitation in some cases was seen as a means for promoting urban development (e.g. La Saône, Emscher). These reported negative experiences usually ceased with the rehabilitation. In a few cases, however the total remediation of these factors could not be achieved, usually due to factors that could not be changed (Wienfluss-Auhof, Fosso della bella Monaca)

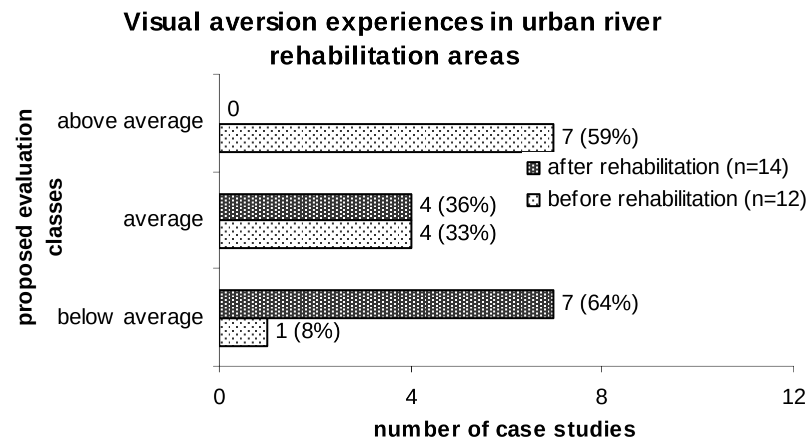


Figure 41: Visual aversion experiences in urban river rehabilitation areas

Overall acceptance of urban river rehabilitation sites

Successful urban river rehabilitation schemes lead also to improvements of urban social life. Thus the measurement of the overall acceptance of rehabilitated sites should be an important issue in implementation appraisals. However, only just more than half of the cases studies could respond to parameters reflecting acceptance.

In almost all the case studies for which responses were obtained, the value of the parameters 'frequency by local population', 'frequency by tourists' and 'frequency by school classes' were perceived to have increased, reflecting a general approval of the reshaped sites (Figure 42).

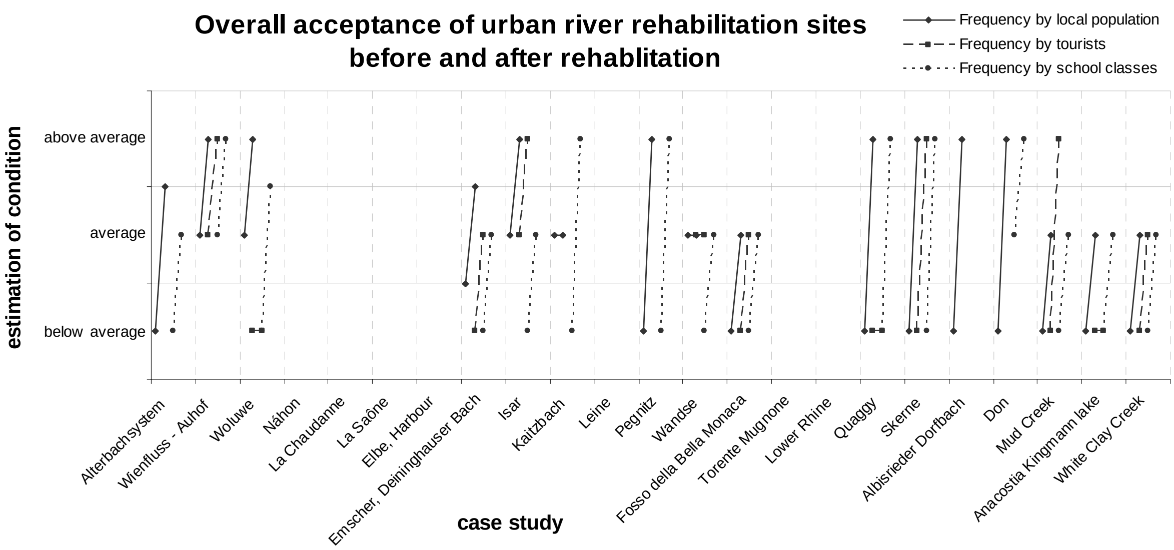


Figure 42: Overall acceptance of urban river rehabilitation sites before and after rehabilitation

Many responses were obtained referring to the frequency of visits by the local population (Figure 43). The increase often was described with the words "definitely" or "dramatically". Most cases were classified 'below average' prior to rehabilitation. Following implementation of the rehabilitation schemes site attendance by local population increased in all but two of the responding cases. This once more indicates the social importance of rehabilitation measures along urban water courses.

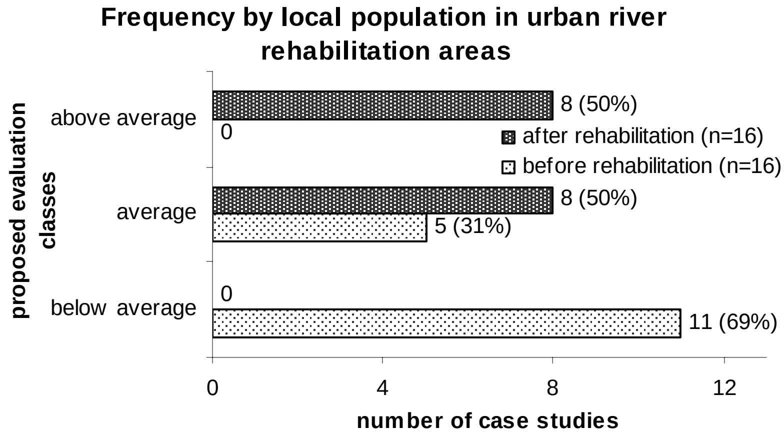


Figure 43: Frequency by local population in urban river rehabilitation areas

The tendency of visits by school classes to rehabilitation areas was seen as an important criterion for the site suitability for education (Figure 44). However, only 14 case studies responded on this issue. However, the responses clearly indicated that the frequency of visits to most of these sites by school classes (86 %) prior to rehabilitation was 'below average'. Following rehabilitation a large number (43 % above average) of sites seems to offer considerably more features that attract school classes while the majority (57 %) had moved to an 'average' state.

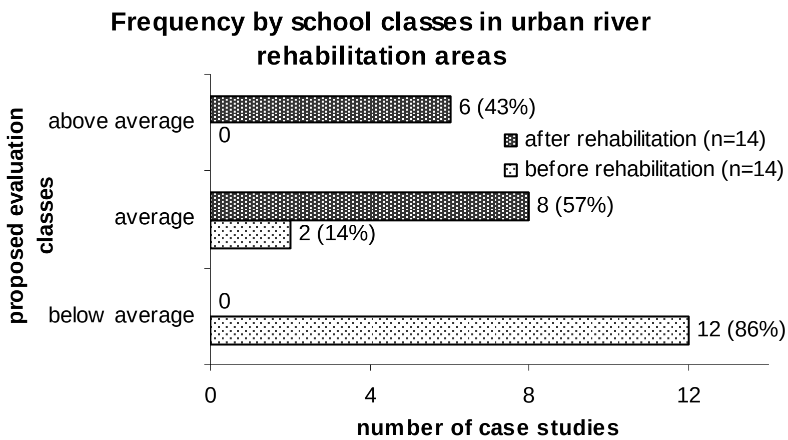


Figure 44: Frequency by school classes in urban river rehabilitation areas

6.2.1 Aspects of economic well-being

Economic aspects play a role in urban river rehabilitation projects in terms of the benefits that an urban area can derive from the improvement of ecological and societal functions of a water body. Many of the considered schemes were explicitly targeting these urban benefits (Chapter 3). However, despite the large interest, the measurement of economic benefits poses a problem in terms of selecting and applying indicators. Within the scope of this study a number of parameters were proposed to measure possible economic impacts of the schemes (Chapter 9). These were assessed using a three-step classification before and after implementation and in addition figures substantiating the shift were requested.

Responses showed that it is difficult to provide even a qualitative description of the changes. A typical answer was "Yes, it has certainly changed, but …". Some partners reported that the change has been positive in terms of economic gains for the near by properties. Only exceptionally the assumption about the economic benefit can be based on documents, as in the case of the Quaggy river where increased property values were reported in news paper articles (London Evening Standard 20.08.2003).

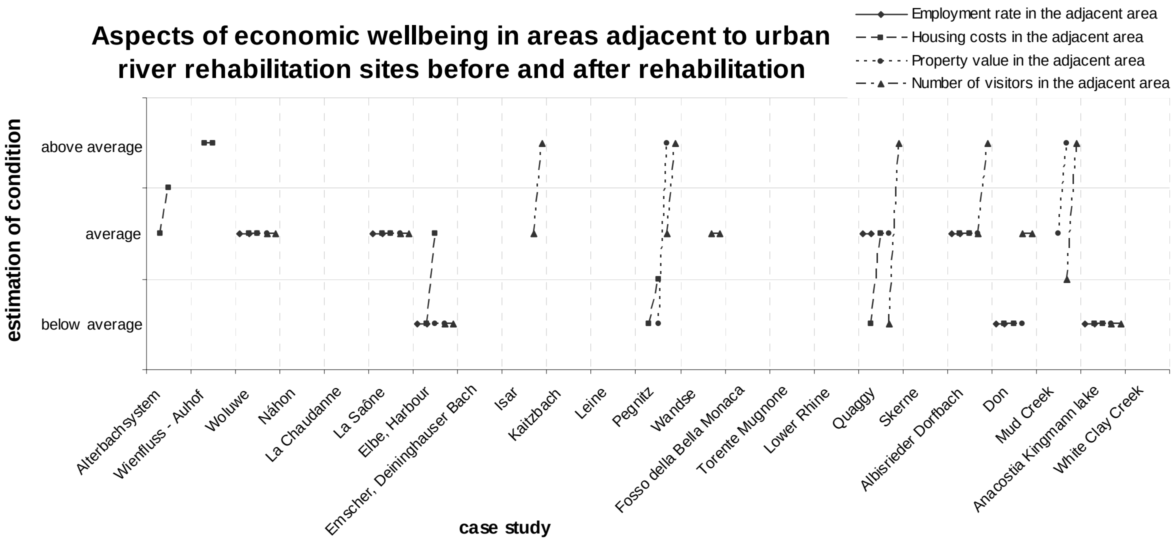


Figure 45: Aspects of economic wellbeing in areas adjacent to urban river rehabilitation sites before and after rehabilitation

Though there was great interest in these aspects, interesting only a few of the partners tried to estimate the economic impacts caused by the rehabilitation scheme (Figure 45). The proposed parameters that received at least a few responses were 'Employment rate in the adjacent area', 'Housing costs in the adjacent area', 'Property value in the adjacent area' and 'Number of visitors in the adjacent area'.

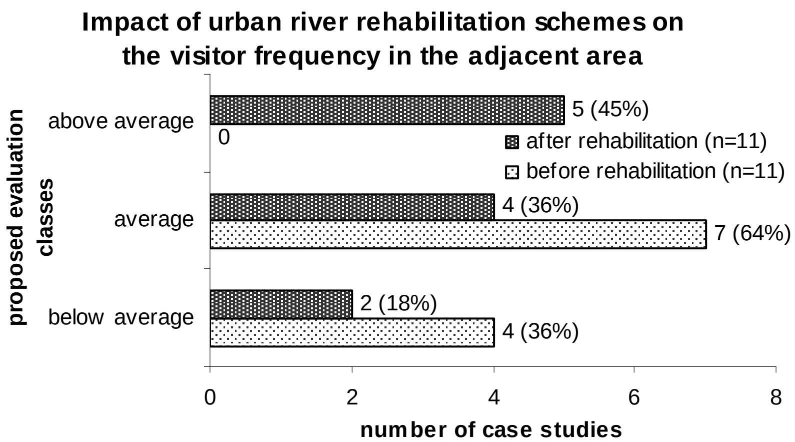


Figure 46: Impact of urban river rehabilitation schemes on the visitor frequency in the adjacent area

Most responses contained information on the parameter "visitor frequency". This can be relevant for the development of economic activities. It appears obvious that river rehabilitation is capable of attracting visitors to the wider area (Figure 46). This may also be seen as indicating an improved basis for the establishment of economic activities addressing related target groups. However, the assumption remains qualitative as in no case could the number of visitors be given by the respondents.

Also in the case of the parameter "property value" no quantification was possible. A relatively high number of responses estimated that no significant change had occurred as a result of the rehabilitation scheme (Figure 47).

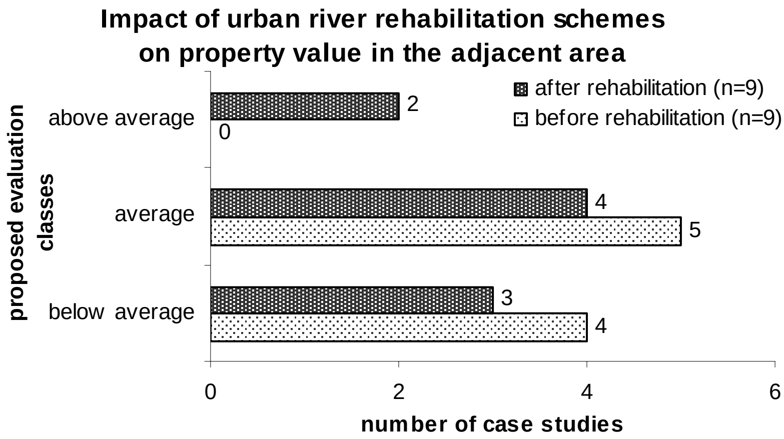


Figure 47: Impact of urban river rehabilitation schemes on property value in the adjacent area

A very similar pattern was shown by the parameter "housing costs". While no numbers were available only a slight shift was reported by two schemes. Worth mentioning, however, is that both, property value and housing costs were reported to be below average in areas prior to river rehabilitation.

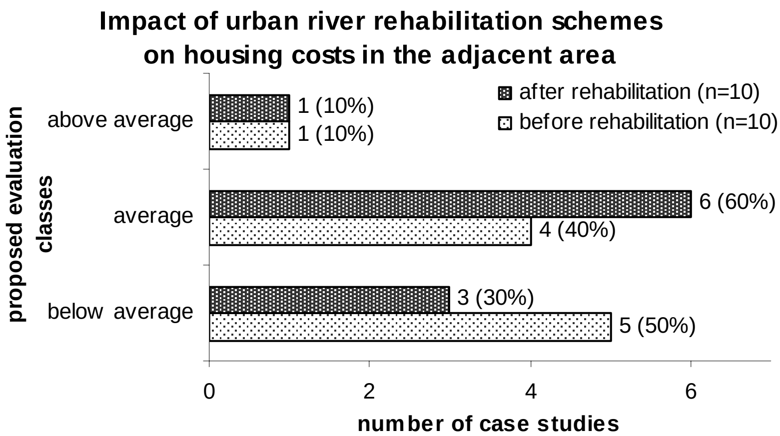


Figure 48: Impact of urban river rehabilitation schemes on housing costs in the adjacent area

Due to the fact that hardly any responses were obtained referring to the parameter "employment rate", it can be assumed that schemes chosen for the study did not impact significantly on this issue. In many cases the schemes were surrounded by housing and so the potential commercial impact was likely to be small. Riverfront developments, which often also include the potential for improvements for commercial use, have not been included in the case studies, since these predominantly address economical, recreational and aesthetical features, using the river as one element. Ecological features of urban waters are usually not improved by such schemes. In Europe no case study with accessible data could be identified combining river rehabilitation and riverfront development.

7 Aesthetic evaluation methods

7.1 State of the art

The aesthetic[3] evaluation of an urban river environment is a specific task within the much larger field of landscape assessment. A short excursion will be taken into the professional field of landscape assessment to assist readers in the interpretation of the findings of the case studies. Within this chapter the term landscape applies to both, natural, more or less unaltered landscapes, as well as anthropogenic landscapes, including rural and urban landscapes.

To this day, there is no commonly acknowledged and widely used aesthetic evaluation method to assess landscapes. This situation prevails, even though landscape beauty and its conservation have been established as an acknowledged societal value and goal. Aesthetic evaluation primarily relying upon scientific parameters and measurements has been a focus of an interdisciplinary discussion during the last two decades. There are opinions that these scientific approaches cannot, and will not, embrace the complexity of aesthetic landscape experience. Thus it is highly improbable that even in the future an evaluation method will be established that will be acceptable to all (Wöbse 2002).

Existing aesthetic assessment methods can be divided into two categories: *expert assessment* and *user surveys* (CESUR-IST/UTL 2003). Expert methods are conducted through individual experts that act more or less independently from user respectively stakeholder groups. These assessments rely upon generally accepted public values of aesthetics. If these values are known, they need not be the subject of new inquiries. Thus expert methods are more time and cost efficient than user surveys, but are partly subject to expert's opinion. User surveys, also called user-dependent methods, ask actual or potential users of the landscape for their opinions, which are then analysed and presented. Because of the high costs involved, surveys are primarily used when new knowledge needs to be gained, or when established values are called into question. In relation to urban river rehabilitation, such user dependent surveys will only be applicable and effective for bigger schemes or e.g. citywide water rehabilitation programmes. In some cases both approaches may be combined.

Independently from the approach taken, diverse aspects influence aesthetic experience and consequently aspects affecting perceived landscape quality must be considered. Thus, for an aesthetic evaluation, the complexity of human senses needs to be taken into account as well as the diverse aspects of recreational usability, which influence experience, satisfy or dissatisfy personal expectations and values and hence affect the subjective perception of an urban river site. Especially in densely populated urban areas, river sites are subject to diverse expectations, e.g. for recreation possibilities and offers for the individual or for interest groups.

Existing assessments are mostly based on, and limited to visual aspects, which has also been true for the relevant case studies. This can be traced back to existing, nearly objective, methods that use quantitative and qualitative criteria to evaluate visual perception. Nevertheless, only relying upon visual aspects cannot account for the overall sensory experience within the existing landscape. Only a few case studies paid attention to noise and

[3] The word "aesthetics" is derived from the Greek word "aisthanesthai" and means perception.

smell. Aspects of recreational usability, including accessibility, were especially valued along urban rivers. In the case studies those aspects have been assessed in combination with aesthetic aspects, since aesthetically pleasing surroundings are seen as a prerequisite for recreational use. Due to these findings, recreational usability will be assessed in addition to the primary aesthetic aspects. Although at least visual and recreational aspects were a consideration in most case studies, only a few methodical approaches have been used. This is even more astonishing as the enhancement of urban quality (chapter 3), where aesthetics and recreation are very important factors, played a major role in the case studies. This might be seen as a direct implication of a popular expectation, that aesthetic enhancement is a side effect of ecological enhancement (Nohl 1998).

It should be taken into account that the data enquiry form that was used not only asked for aesthetic evaluation methods, but also whether measures to enhance the aesthetic experience have been implemented and if an improvement had taken place. Consequently the twenty-three case studies have been analysed on the basis of the following questions:

- Which aesthetic aspects were taken into account in the river rehabilitation projects? Questions related to aspects of vision, spatial feeling, acoustics, olfactory aspects and usability.
- Have these values been assessed through an evaluation method? If so, which methods were used.

7.2 Aspects of aesthetics considered in urban river enhancement

The enquiry on the aesthetic aspects included aspects of vision, spatial feeling, acoustics, olfactory senses and recreational usability of the river and river corridor. Table 15 gives an overview of which of these aspects had been taken into account within the case studies. The table is based upon a blend of answers concerning aesthetic enhancement (Part B of the enquiry form, see Annex 1) and implemented measures (Part C of the enquiry form) to reach this enhancement.

Visual and spatial aspects were considered in about three-quarter of the rehabilitation schemes of the case studies. These aspects were enhanced through measures such as the establishment of viewpoints, clearing of vegetation and others. Despite the fact that these aspects had not obviously been approached using an explicit methodology, some kind of evaluation procedure can be assumed to have been used within the site design. In one quarter of the case studies visual or spatial aspects had not been considered. It is assumed that this could be due to several reasons, such as the small size of the projects (Elbe), the location of the project at the periphery of an urban area (Wienfluss-Auhof, Lower Rhine) or concentration on other issues (La Chaudanne), where aesthetic assessment was of no direct relevance.

Aspects of smell and sound have been referred to within about 35 % of the case studies. These have been considered rather implicitly compared to the visual and spatial aspects. In the Zurich example (Albisrieder Dorfbach) sensory experience had been recognised by citizens and mentioned with a very positive connotation. Nevertheless, there has been no real survey of these aspects, nor has it been taken into account during the planning process. Noteworthy is that sensorial stimulation has been, and still is being used as an argument for daylighting brooks (Entsorgung + Recycling Zurich 2000).

Table 15: Consideration of aesthetics and usability

	Alterbachsystem	Wienfluss-Auhof	Woluwe	Nâhon, Chrudim	La Chaudanne	La Saône, Lyon	Elbe, Hamburg Harbour	Emscher, Deininghauser Bach	Isar	Kaitzbach	Leine	Pegnitz	Wandse	Fosso della Bella Monaca	Torente Mugnone	Lower Rhine	Quaggy	Skerne	Albisrieder Dorfbach	Don, Chester Springs Marsh	Mud Creek	Anacostia, Kingman Lake	White Clay Creek	**Total YES (n = 23)**	**Total YES (%)**
A	x		x	x		x		x	x	x	x	x		x			x	x	x	x	x	x	x	**17**	**74**
B	x			?			?			x			x	x				x		x	x		x	**8**	**35**
C			x	x									x	x			x	x				x	x	**8**	**35**
D	x	x	x	x			x	x	x		x	x		x	x	x	x	x	x	x	x	x		**18**	**78**
E		x	x	x			x	x	x	x		x		x		x	x	x	x	x	x	x		**16**	**70**
F			x				x							x	x		x	x	x		x			**8**	**35**
G												x									x	x		**3**	**13**

x = yes, **?** = no clear statement

A: Visual and spatial aspects, **B**: Smell and sound, **C**: Remedy of aversion experience, **D**: Aspects of accessibility, **E**: Aspects of social and cultural infrastructure, **F**: Aspects of accident prevention, **G**: Aspects of public health

Recreational usability, which influences aesthetic experience of the site, can be seen as a function of accessibility and an investment in the social and cultural infrastructure. Accessibility has been considered in more than three-quarters of the case studies, which included access for cars, public transport and soft modes of transportation. Those which did not deal with these aspects, usually already displayed adequate accessibility. This confirms the importance of movement in relation to river corridors. The improvement of social and cultural infrastructures has been marked as important in 70 % of the case studies. Included are measures to strengthen the identity and peculiarity of the riversides by highlighting cultural heritage and improving knowledge about sites through e.g. the use of signs or guided tours.

The case studies were also analysed for the remediation of aversion experiences, such as protection from noise and pollution. Such measures have only been applied within about one third of all cases. It can be assumed that due to urban complexity and competing land uses constraints these aspects are difficult to remedy. Nevertheless, depending on the source of aversion, aversions can be minimised through e.g. an increase of security or noise mitigating measures. Measures for accident prevention, such as installing railings and lowering of stream banks, can also contribute to this objective. This has been considered by one third of all case studies. Public health has been considered by 13 % of the case studies. This may be ascribed to the fact, that water quality, in this sense the main factor influencing public health, has not been a limiting factor in most case studies. Aesthetic aspects and aspects influencing the subjective perception were a consideration in most cases. They mostly related to visual aspects, aspects of accessibility and enhancement of recreational values. The latter is expressed by investments in social and cultural infrastructure.

7.3 Applied aesthetic evaluation methods

In the absence of a common understanding of the aesthetics of urban river enhancement, the study result has to be regarded with caution referring to methodical approaches to aesthetic evaluation. Even despite a second survey by the project team, only approximately one third of the case studies could report the use of an aesthetic evaluation method.

Table 16: Aesthetic evaluation methods used in the case studies

	Alterbachsystem	Wienfluss-Auhof	Woluwe	Náhon, Chrudim	La Chaudanne	La Saône, Lyon	Elbe, Hamburg Harbour	Emscher, Deininghauser Bach	Isar	Kaitzbach	Leine	Pegnitz	Wandse	Fosso della Bella Monaca	Torente Mugnone	Lower Rhine	Quaggy	Skerne	Albisrieder Dorfbach	Don, Chester Springs Marsh	Mud Creek	Anacostia, Kingman Lake	White Clay Creek	**Total YES (n = 23)**	**Total YES (%)**
	x								x	x		x						x			x		x	**7**	**30**

x = yes, **?** = no clear statement

Expert assessment

Expert assessment of aesthetics has either been part of the planning assessment (Altenbachsystem, Skerne), landscape design or landscape assessment, or it has been conducted independently (Kaitzbach). Due to the limited findings of the case studies, no common statement can be made. For clarification some examples will be described below.

The following gives descriptions of two examples of expert assessment identified in the case studies. Both assessments used descriptive approaches.

Skerne river (Darlington)

Within the Skerne case study, aesthetic values were approached within a landscape assessment. The approach was based on a methodology developed by the National Rivers Authority, UK (NRA 1993). The assessment included the description and the classification of each river section into elements or character areas and an evaluation, which identified individual management needs for each section.

Evaluation was done on both a macro and a micro scale, first describing the overall character and latter describing single elements of the site and their value for perception and recreation. Micro scale was described in terms of:

- River Channel – Banks
- River Margins
- Appearance of water
- Notable/characteristic features
- Brief description and landscape character
- Evaluation

The evaluation was based on a 5-point scale; the five classes were connected to a management strategy classification, which included conservation, restoration, enhancement and management. Those goals were then presented on a site plan, where the evaluation of the macro and micro scale was combined and transferred into the proposed management actions.

Alterbachsystem (Salzburg)
The river rehabilitation scheme in Salzburg is distinguished through a comprehensive site analysis and succeeding monitoring of the rehabilitated site. Within the scheme the following aesthetic aspects have been considered during the site analysis: ▪ Nativeness (natural landscape structure and elements, characteristic vegetation) ▪ Variety/diversity (sensual perception, time variance) ▪ Harmony (relation to surrounding environment) ▪ Accessibility of stream corridor/stream The river site had been divided, based on structural characteristics, and was then classified. Prior to the assessment, a reference section for the brook was defined matching the highest value on a 5-point scale. The five quality classes were verbally described to provide a guideline for onsite evaluation. On a diagram the actual state and the potential development of the future aesthetic appearance was displayed. A subsequent evaluation of aesthetics took places as part of a comprehensive river success control. It used the concept of accessing the visual quality of the landscape. Relevant data have been assessed during site visits in spring and autumn, impressions were verbally noted and pictures taken. Elements, that were mapped for evaluating experiences, included the following aspects: • Sinuosity • Currents dynamics • Structure and morphology of river bed • Form of banks and connection to the surrounding cultural landscape • Bank vegetation • Characteristics with special peculiarities (e.g. entrance situations) • Acoustical, visual and other sensual perceptions as animal noises and seasonal aspects Additionally to the mapping of these elements, researchers talked to adjoining property owners to find out about acceptance and relevance of the project. Based on the assumption that aesthetics is a value measured by human standards, the mapped elements were classified through four qualities, related to human perception: • Variety/diversity – satisfies the human need for information, change and renewal - diversity of rivers is e.g. found in the manifold appearance of flowing waters, contrasts, light, and colour effects. A component of time is related to the seasonal and daily change. • Originality for a river relating to dynamics of river flow, continuity and native plant communities. • Peculiarity – specific characteristics that make an element outstanding from the rest, creating feelings of identity. Peculiarity is closely connected with the symbolic meaning of landscape elements. • Closeness – The relationship of all elements towards each other - e.g. consistency of dimension, material and shape and content the human need for orientation, completeness, consensus (harmony) as well as satisfaction. Results of the on-site evaluation were displayed in a diagram, reflecting the actual state and the potential development of the future aesthetic appearance.

In addition to these two descriptive approaches, an example will be presented which was not found in the case studies, but in the literature review. In this case aesthetics were considered on a macro scale and its evaluation used ordinal scaling:

The Kentucky River assessment (Kentucky Division of Water 1992) was a Kentucky State (U.S.) effort to assess the existing and potential values of rivers in Kentucky. Categories defined by river experts were chosen to display the important values afforded by rivers. This included ecological, social, economic, cultural and aesthetic aspects. The latter has been displayed within the categories *"Corridor character"*, *"Cultural resources"* and *"Geologic and scenic features"*.

Corridor Character: Two sub-categories were established for this category: undeveloped rivers and urban rivers. The urban river category is considered here. It is defined by the river's location in or adjacent to urban areas. The evaluation of urban rivers was based upon the physical characteristics of the river, the existing and potential access and the existing and potential shoreline character. Segments with the greatest variety and a number of diverse characteristics were determined to be of greatest value to the adjacent community. In order to be included in the evaluation process, each river had to achieve a certain length, a certain population number, cultural or historical significance and orientation of the community towards the river. The following criteria were evaluated, taking into account the needs of an urban environment:

- Use of opportunities with respect to flow consistency, river width and water quality (high: 30 pt, medium: 20 pt, low: 10 pt)
- Existing access for boating, fishing and viewing (high: 30 pt, medium: 20 pt, low: 10 pt)
- Potential access for boating, fishing and viewing (high: 15 pt, medium: 10 pt, low: 5 pt)
- Existing natural, cultural or historical character and amenities, open space, community orientation to the river (high: 30 pt, medium 20: pt, low: 5 pt)
- Potential improvement or restoration of shoreline quality (high: 15 pt, medium: 10 pt, low: 5 pt)

Where rankings fell between the criteria, points were adjusted. Rivers with a total score of less than 50 points were removed from the list. The remaining rivers were ranked into three value classes with class 1 having the highest value (Class 1: 120-100 points, Class 2: 99-70 points, Class 3: 69-50 points). The following categories were evaluated, based on the same methodology, so only the criteria upon which rivers were classified will be stated.

Cultural resources:

- Rural historic site not on the national register of historic places (1 point)
- Rural historic site listed in or determined eligible for listing in the national register of historic places (2 points)
- Rural archaeological site not listed on the national register of historic places (1 point)
- Rural archaeological site listed in or determined eligible for listing in the national register of historical places (3 points)
- Urban centre with an historic site on riverbank, including all incorporated cities (25 points)
- Historic district site listed in or determined eligible for listing in the national register of historical places (25 points)

Geologic and scenic features:

Scenic quality is described as a function of the diversity, frequency, unique characteristic of various natural and cultural components and the relationship between these components.

The greater are the variety and contrast, the higher is the scenic value. The evaluation took into account a corridor of 600 metres on each side of the riverbank. It was based on the following criteria:

- Landscape diversity - the amount of diversity (variety) is a measure of the scenic value in a particular landscape. The scenic value of a river corridor will be enhanced when there is a diversity of landforms, rock formations, vegetative patterns and water form (no point scale provided).
- Corridor width - the width of a corridor relative to its relief or the amount of enclosure has substantial effects on its scenic quality. Narrow corridors enclosed by high, steeply sloped landforms have significant scenic values (no point scale provided)
- Water clarity - the visual clarity of the water is a significant factor determining scenic quality. An abundant supply of clear water significantly enhances scenic value (no point scale provided)

This approach is not only focused on the urban environment, but provides one way of evaluating aesthetics, whereas, for example, scenic quality is another way to do so.

User surveys

Alternatively, user surveys have been used for an aesthetic evaluation of urban rivers. Three case studies show these being applied in various ways and to various extents. For the Isar as well as the Kaitzbach, user surveys with a statistical background were conducted, while the questioning in Nuremberg was based on a random approach to residents as a part of the site design analysis. The approach for aesthetic evaluation of the Isar corridor in Munich was to conduct interviews of walkers, fulfilling statistical requirements. The approach was limited to assessing mainly the visual aspects only. Additionally, aspects of recreation and usability were examined. At the Kaitzbach, psychologists conducted surveys with diverse user groups, including aesthetic, social and recreational aspects. Both surveys are described below.

Kaitzbach (Dresden)
User surveys with diverse user groups were conducted at the Kaitzbach (see chapter 8). In addition to the problem-oriented interviews, an alternative approach was used, which was to search for impressions of people walking along the brook and to find out about the diverse expectations and ways of perception. For this purpose walks with groups of ten people along the brooks where organised. Participants were asked to express anything they were experiencing and thinking about during the walk. The monologues were recorded. Diverse impressions and thoughts, stories and explanations were sorted and verbally summarised under themes such as perception and memories of the brook (e.g. childhood memories). During the walks many interesting aspects and views were discovered, supplying additional information to the user-oriented surveys. Acquired information was interesting enough to be considered within official planning documents. However, no real evaluation of the collected data was carried out. Instead, a descriptive summary of the expressed impressions was presented.

Isar (Munich)
The Bavarian Nature Conservation Law provides the right for enjoyment of natural beauty and recreation in nature. Empirical surveys on landscape aesthetics and recreational values were conducted for the “Isarplan” (Nohl, W. 1998). A survey was prepared, to evaluate the aesthetic experience of the Isar valley landscape. Additionally a count of users was prepared, considering diverse function of river sections and different points in time. The survey provided a basis for a differentiated assessment of aesthetic values of the water body and pointed out quality and constraints of visual appearance. The investigation of aesthetic experience was based on the use of coloured photographs, which were taken under certain photographic rules, such as: • Consistency within the pictures relating to weather, cloudiness, water level, foliation, frequency of users • Overview pictures with the same composition of pictures (foreground, middle ground, background) • Using focal widths of lenses reflecting the perspective of the human eye etc. It has been proven that no more than 15-25 pictures on one topic should be presented to the respondent during a survey. Consequently the number of pictures taken was limited to two per section, accounting for 22 pictures of 12 sections all together. As instrument for the survey a compulsory distribution of these pictures in five classes (1= I like the most to 5 = I don’t like at all) was given to the respondent: 2 pictures for category 1 and 5, 4 pictures for category 2 and 4 and 10 pictures for category three. With this requirement a normal distribution could be established to meet statistical standards. The arithmetic average of all the responses to each picture was calculated. Then the values of the two pictures of each section were added up and divided by two, which established the specific value of aesthetic experience in each section of the river (Nohl, W. 1998).

8 Social appraisal and stakeholder involvement

Within the last decades public involvement has proved to be a key factor for successful project implementation. It is acknowledged to increase the acceptance of projects and helps to achieve social sustainability. In 1998 the Aarhus Convention on access to information, public participation in decision-making and access to justice in environmental matters formed a European-wide legal background (UNECE 1998). Now legislation in most European states requires public information and participation in the determination phase of a planning process, though in some countries smaller sized projects may not be subject of public participation requirements. With the adoption of the WFD, new requirements for public participation have been established and have to be put into practice during the next few years. "The success of this Directive relies on close cooperation and coherent action at Community, Member States and local level as well as on information, consultation and involvement of the public, including users" (WFD 2000, preamble/14). Consequently, in future not only consultation but moreover active involvement is to be encouraged by the Member States. These new standards exceed most existing legislation, requiring continuous consultation during a determination phase. Practical implementation of public participation as required by the WFD is promoted by the Document "*Guidance on public participation in relation to the WFD – active involvement, consultation and public access to information*", the application of which is currently being tested (European Commission 2003).

The following chapter analyses the schemes on the extent of public participation and for tools, which have been used, to effectively inform, consult and finally to actively involve the public and other stakeholders. Despite rather little developed legal requirements, most case studies have been found to represent good examples of public participation that may also serve as examples for site-specific participation for the implementation of the WFD. A diversity of approaches with differing emphasises and different extents, have been identified. It was found that projects large in terms of duration and costs, showed the most extensive public participation. Especially the North American case studies are characterised by comprehensive efforts to involve many stakeholders, including citizens, NGO's, commercial associations, single businessmen and politicians.

8.1 Legal requirements for public participation

Legal requirements for public participation in urban river enhancement schemes existed in almost half of the projects (48 %; Table 17). Most of those were limited to public information and written consultation within the determination process of a plan (Leine, Lower Rhine, Emscher, Isar, Altenbachsystem). Only a few projects were backed by legal requirements for public hearings, discussions (Albisrieder Dorfbach) and oral consultations. In addition three schemes financed by the European Union (Skerne, Fosso della Bella Monaca, Lower Rhine) were required to actively involve stakeholders as a prerequisite for financial aid.

Disregarding the degree of involvement, public participation occurred in more than 80 % of the rehabilitation projects, even though it was not always legally required. Involvement ranged from plain public information up to comprehensive efforts for active participation, including voluntary work during implementation. Within more than half (60 %) of the projects legal requirements were exceeded.

Table 17: Legal requirement for public participation in urban river rehabilitation projects

	Alterbachsystem	Wienfluss-Auhof	Woluwe	Nāhon, Chrudim	La Chaudanne	La Saône, Lyon	Elbe, Hamburg Harbour	Emscher, Deininghauser Bach	Isar	Kaitzbach	Leine	Pegnitz	Wandse	Fosso della Bella Monaca	Torente Mugnone	Lower Rhine	Quaggy	Skerne	Albisrieder Dorfbach	Don, Chester Springs Marsh	Mud Creek	Anacostia, Kingman Lake	White Clay Creek	Total YES (n = 23)	Total YES (%)
A	x				x			x	x		x			x	?	x			x	x	x		x	11	**48**
B				x			x	x	x	X		x	x	?	?	?	x	x	x	x	x	x	x	14	**60**
C	x		x		x		x	x	x	X	x	x	x	x	x	x	x	x	x	x	x	x	x	20	**87**

x = yes, **?** = no clear statement

A: Legal requirements, **B**: Legal requirements exceeded, **C**: Projects with any kind of public participation

8.2 Stakeholders

Stakeholder groups

Different stakeholder groups were found to participate in urban river rehabilitation projects. These ranged from informal citizen groups, non-government organisations and other social groups to political groups and commercial associations respectively single businesses.

Table 18: Involved stakeholders

	Alterbachsystem	Wienfluss-Auhof	Woluwe	Nāhon, Chrudim	La Chaudanne	La Saône, Lyon	Elbe, Hamburg Harbour	Emscher, Deininghauser Bach	Isar	Kaitzbach	Leine	Pegnitz	Wandse	Fosso della Bella Monaca	Torente Mugnone	Lower Rhine	Quaggy	Skerne	Albisrieder Dorfbach	Don, Chester Springs Marsh	Mud Creek	Anacostia, Kingman Lake	White Clay Creek	Total YES (n = 23)	Total YES (%)
A				x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	20	**87**
B			?		x			x	x				x										x	5	**21**
C				x	x		x	x	x	x	x	x	x			x	x		x	x	x	x	x	16	**70**
D								x		x			x				x			x		x	x	7	**30**
E	x				x	x		x		x			x	x		x				x			x	10	**43**

x = yes, **?** = no clear statement

A: Citizen, **B**: Political groups, **C**: Non-government organisations, **D**: Commercial associations / single businesses, **E**: Other social groups

Citizen groups include residents, private property owners and other interested persons. These informal groups have been involved in more than 80 % of the case studies and account for the most important stakeholder group, contributing in diverse ways to site selection and collection of ideas as well as the planning and implementation of schemes.

National, regional and local non-government organisations (NGOs) have been involved in two-thirds of the case studies and shown to be the second most important group of stakeholders. NGO's included in this category are as follows:

- Community, neighbourhood or district groups (Quaggy)
- Nature conservation organisations or societies with common or special interests (e.g. ornithologist groups, Toronto Wildflower Society, Anacostia Watershed Society, Earth Conservation Corps, Quaggy River Action Group)
- Diverse user organisations, such as biker, angler, canoeists, and hunters (e.g. Isar, La Saône)
- Task Forces with a relation to the location (e.g. Isar Valley Interest Group, German Alpine Cooperation)
- Inter-cooperation of diverse NGO's (e.g. Isar, Don River, White Clay Creek)

Commercial associations (e.g. tourism and others) or single businesses actively participated in one quarter of the projects. There have even been programmes to involve the private business sector. An example is the Anacostia River Business Coalition in Washington (chapter 8.6).

Politicians or political groups have been actively engaged in about one fifth of the projects. There also are indications of a lack of political interest in river rehabilitation, most evident in the Kaitzbach case study in Dresden where it was particularly hard to win political support. The Quaggy case study in London has shown that it often needs time and much effort to achieve the necessary political backing. Other river programmes in turn have been a great political success. An example is the case study of the "Isar Plan" in Munich. Here river rehabilitation was included in the political platform of several political parties, who declared in their election campaigns that the rehabilitation of the river was very important to them.

There also have been other participants in urban river rehabilitation projects, in addition to the stakeholder groups already mentioned. The list includes but is not limited to schools and youth groups, public and private research institutes, universities (Isar, Kaitzbach, Emscher, Alterbachsystem), artists (Kaitzbach) and employees from government work creation schemes (Kaitzbach, La Saône). Diverse concepts and ideas on how to involve citizens and other stakeholders will be described in Chapter 8.5.

Identification of stakeholders

Identification of stakeholders and decisions on how and whom to involve in a river rehabilitation project is an important first step for an effective project organisation as well as for the social sustainability of the project. Despite broad levels of participation only two approaches on identification of stakeholders could be found (Kaitzbach, Skerne). Within most case studies, stakeholder identification was based on experience with similar projects and local knowledge of who will be directly and primarily affected by the project.

General guidance on this issue is given by the "Guidance document No 8 - Public Participation in relation to the Water Framework Directive, Annex 1" (European Commission 2003), which presents a stakeholder analysis technique. This analysis tool enables the practitioner to prioritise which stakeholders are vital to a certain issue in a specific phase of the project.

Further help on the identification of stakeholder comes from the World Bank Participation Sourcebook (World Bank 1996):

"No hard or fast rules exist to tell us whom to involve and how. What we do know is that stakeholder involvement is context-specific; what works in one situation may not be appropriate in another. Trusting and using one's judgment, therefore, may be the best advice Project Managers can give each other at this point in time."

A good way to identify appropriate stakeholders is to start by asking questions. Suggestions for questions are not an exhaustive list but rather a preliminary road map:

- Who are the "voiceless", for whom special efforts may have to be made?
- Who are the representatives of those likely to be affected?
- Who is responsible for what is intended?
- Who is likely to mobilise for or against what is intended?
- Who can make what is intended more effective through their participation or less effective by their non-participation or outright opposition?
- Who can contribute financial and technical resources?
- Whose behaviour has to change for the effort to succeed?"

After the identification of all potential stakeholders, a decision on who of them should be involved, needs to be taken. This decision depends on former project experience and local knowledge. Assistance can also be gained from local residents, as was employed in the Skerne case study (see below). A social - psychological study was used in the Kaitzbach case study (see below).

Kaitzbach (Dresden)

A social - psychological study was conducted at the Kaitzbach assisted through a federal grant (Schmidt-Lerm, Wolf 1994). Objectives of the study included understanding the comprehensive relations, perceptions, views and problems relating to an urban stream.

At the beginning stakeholders with spatial, personal or factual relations were identified, who then were invited for discussion and communication in public meetings. Prior to direct contact they had been informed via bulk mail (bigger groups) or contacted via phone. Identified stakeholders for the survey included the following:

- Administrations connected to the Kaitzbach (at regional and city levels)
- Politicians living within the catchment basin as future representatives of diverse interests related to the brook
- Neighbours of the Kaitzbach area within different sections of the brook as actual or potential users
- Users without economical interests (people met during survey along the brook)
- Local initiatives, such as nature volunteers, and neighbourhood groups
- User groups with economic interests such as investors, craftsmen, industrialist, farmers
- Users with public interests as sports and recreational facilities.
- Other interested people

In addition to these predefined stakeholders a survey identified groups of people, who would regularly use places along the brook.

Skerne River (Darlington)
As part of a European Union LIFE Natura 2000 project a demonstration site was chosen in Darlington, UK, to implement innovative rehabilitation techniques along the Skerne river at its entrance into town. The approach taken to involve the public consisted not of the usual various public meetings and workshops but a purposeful individual involvement of different groups and individuals. For this reason a local Liaison Officer was employed to facilitate public involvement. This person was a local resident with social and integrating capabilities. In the course of the planning and implementation phases the Liaison Officer organised two public meetings and was responsible for producing and distributing information material. The Officer participated in meetings of local resident groups, talked to residents to inform them about what was planned and asked for opinions and proposals. As a result some of the persistent scepticism was reduced (RRP 1997).

8.3 Informing stakeholders

A prerequisite for meaningful public participation is to inform stakeholders about the conditions of a river or a specific river rehabilitation project. Information helps to win stakeholder support for a project, promotes stewardship, advocacy and initiates participation. Through understandable, user-oriented information awareness for urban streams and their specific problems can be increased and citizens can be enabled to participate in a consultation processes. A great variety of approaches have been used to inform citizens and stakeholders utilising various media and methods of distribution (Table 19). Also the type and amount of information provided during the planning phase varied greatly.

Table 19: Ways of informing stakeholders

	Alterbachsystem	**W**ienfluss-Auhof	**W**oluwe	**N**áhon, Chrudim	**L**a Chaudanne	La Saône, Lyon	**E**lbe, Hamburg Harbour	**E**mscher, Deininghauser Bach	**I**sar	**K**aitzbach	**L**eine	**P**egnitz	**W**andse	**F**osso della Bella Monaca	**T**orente Mugnone	**L**ower Rhine	**Q**uaggy	**S**kerne	**A**lbisrieder Dorfbach	**D**on, Chester Springs Marsh	**M**ud Creek	**A**nacostia, Kingman Lake	**W**hite Clay Creek	**Total YES (n = 23)**	**Total YES (%)**
A	x	x	?	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	**22**	**95**
B		x			x		x	x	x			x	x	?		x		x	-	x	x	x	x	**13**	**56**
C		x			x			x	x	x	x	?	?	?	?	x		x	-	x	x	?	x	**11**	**47**
D		x			x			x	x	x		x	x	?	?		x	x	x	x	x	?	x	**13**	**56**

x = yes, **?** = no clear statement

A: Paper related (brochures, billboards, newspaper/journals), **B**: World Wide Web, **C**: Local TV-Station/Radio, **D**: Presentations, lectures etc.

Project related paper based information was used in all projects. Articles in daily, weekly and occasionally monthly newspapers as well as articles in Journals are a traditional means of communication. Another major method used to inform citizens were project flyers, also called fact sheets, which were usually made available at public places. They document the reason, objectives and proposed measures for the rehabilitation scheme and provide information about the responsible agencies as well as finances. Further paper based media, such as posters in bus shelters and banners with project names have, for example been used in Toronto, CA to promote schemes.

In addition, diverse planning materials have been made available at certain stages of the scheme development process (e.g. drafts or final versions of river enhancement programmes). In some cases assessment summaries and information on special topics such as storm water infiltration measures were distributed. These materials were available just for inspection at public places or could be accessed through the Internet, or could be obtained for free, or at cost price. Information can sometimes be acquired on CDs (Wienfluss-Auhof). For the Isar the responsible agencies published an ISAR Calendar. For the Kaitzbach, a guidebook with historical backgrounds on the brook, constraints and future planning was published. Publications are geared to promote advocacy for urban rivers, providing informative material with various layouts for different target and age groups.

Almost 50 % of the recorded case studies used TV and Radio to inform the public. News releases or short project spots on local radio and TV stations were commonly utilised for the bigger schemes. The Kaitzbach case study, for example used media in various ways. Short radio features, a video on user groups and a production of a longer documentary that showed perception of the brook by various user groups, were created. Several other projects (Wienfluss-Auhof, Isar) have used videos for project documentation.

Sixty percent of the case studies utilised Internet presentations to pass information to a broad public audience. These presentations were integrated into websites of the responsible agencies and sometimes were provided through sites of participating stakeholders. The presentations themselves were multifaceted, ranging from plain project descriptions and newsletters to downloadable documents including guidelines, policies, monitoring reports, and membership applications for interest groups. Several case studies, especially the ones with a long rehabilitation programme, distributed newsletters to stakeholders and residents at monthly, quarterly or annual intervals via the Internet. In two case studies (Don River, Anacostia) progress reports used the achievement of targets as indicators of success to inform the public[4] at regular intervals. Munich residents along the Isar river could take part in a photo competition and view pictures through a website. It was apparent that the larger a scheme (temporally and financially), the more elaborate the presentation tends to be on the Internet.

Information boards of diverse content and design have been installed onsite in many schemes. Information displayed includes problems of the stream, goals and objectives, as well as historical and ecological information. In Munich boards showed pictures of historic and future views of the river while spare windows in between displayed the actual state of the river development. One problem has been that information boards are often vandalised or even completely destroyed (Skerne, Alterbachsystem, Albisrieder Dorfbach). In some case studies, artists have been employed for installations (Kaitzbach, Pegnitz). One example is the "Kunstpfad" (path of arts) along the Kaitzbach. As a first step artists developed temporary installations on a pathway along the brook, which were later converted into permanent installations. Information boards have also been used in combination with bigger exhibits to inform the public (Wandse, Isar, Kaitzbach). Travelling exhibitions were used at schools, public buildings and neighbourhood festivals.

More interactive information sharing can be achieved by guided tours along the brook. Advocacy groups, local tourist agencies, students or project agencies or planners have been used to lead these tours (e.g. Quaggy). They have also been conducted for advocacy reasons, or just to inform interested citizens about the history and ecology of a brook.

[4] For Don River, Toronto see http://www.trca.on.ca/water_protection/strategies/don/; For Anacostia, Washington see http://www.anacostia.net/progress.htm

Information sharing has also taken place during ongoing projects (Alterbachsystem, Emscher), or after the brook has been revitalised to explain measures and the ongoing process of rehabilitation. Special tours, including active water quality testing, were organised for interested groups (Kaitzbach). At the Emscher and its tributaries guided tours through newly constructed sewage water channels are offered and very well visited. This is also the case for the Wienfluss-Auhof scheme.

Lectures or presentations were utilised for communicating the scheme's objectives in two-thirds of the case studies. These included presentations to local, regional, national and international audiences. International presentations were usually connected to projects with a scientific background, where research institutes or universities contributed to the project outputs.

Emscherregion
The Emscher programme uses diverse concepts for communicating information on river enhancement schemes. There are brochures with common information on revitalisation and flyers for every river subproject. Those include information on the history of the stream, stream and project statistics, actual plans for river enhancement, reports on the state of implementation, descriptions of measures and information on responsibilities. A number of pathways for biking or walking tours have been aligned along rehabilitated river sites. Information boards give information on why measures are important for an intact fauna and flora as well as information on the cultural and industrial history of the area. Flyers give information concerning interesting points along the route, such as bike rentals, train stations, restaurants, museums and information points. An overview where these flyers can be obtained is incorporated into the website of the publishing agency Emschergenossenschaft (www.eglv.de, Emscher Corporation). The website of the Emscher Corporation provides information on: ▪ The Emscher Corporation itself (goals, organisation structure and its history) ▪ The programme and its single projects ▪ Storm water management (projects and common information) ▪ Brook sponsorships (what it is and who can become a sponsor) ▪ Explanation of technical backgrounds in a very understandable manner ▪ Exhibitions and events connected to any streams ▪ Actual Information on precipitation and water levels ▪ Information material, archive on press releases

Anacostia (Washington D.C.)
The cooperation between government agencies of the District of Columbia and Anacostia watershed residents is displayed in a broadcast-quality video, educating residents about the need to reduce non-point source pollution to the river. In addition, people are also educated through slide shows. Children and adults can participate in canoe or pontoon boat tours, and Watershed Explorer/ River Habitat education programmes are conducted. Comprehensive websites focus on watershed wide issues and provide information for individuals as well as for experts. Technical fact sheets are downloadable and focus on private households, but also municipal technologies. Watershed relevant data including planning decisions, overviews of rehabilitation projects, and progress gauges for specific restoration goals are distributed via internet and in the "Anacostia Currents", an annual newsletter, published by the Anacostia Watershed Restoration Committee.

8.4 Involving stakeholders in the process

Planning process

In about 40 % of the case studies, citizens have been involved in the site selection for rehabilitation schemes. Either they themselves were the initiators of the project (Mud Creek, Torente Mugnone and others), or they may have been asked by initiators to support site selection through their site knowledge (Albisrieder Dorfbach, Don River). Others helped actively in site analysis that defined the enhancement potential of a stream (Wandse, Anacostia).

Table 20: Citizen involvement

	Alterbachsystem	Wienfluss-Auhof	Woluwe	Náhon, Chrudim	La Chaudanne	La Saône, Lyon	Elbe, Hamburg Harbour	Emscher, Deininghauser Bach	Isar	Kaitzbach	Leine	Pegnitz	Wandse	Fosso della Bella Monaca	Torente Mugnone	Lower Rhine	Quaggy	Skerne	Albisrieder Dorfbach	Don, Chester Springs Marsh	Mud Creek	Anacostia, Kingman Lake	White Clay Creek	Total YES (n = 23)	Total YES (%)
A		x		x	x			x	x			x	x	x			x		x	x	x	?	x	**13**	**56**
B			x	x	x			x	x	x		x	x		x	x	x	x	x	x	x	?	x	**16**	**70**
C					x			x	x	x		?	x		x				x	x		?	x	**9**	**39**
D					x	x		?	x			x	x							x	x	x	x	**9**	**39**

x = yes, **?** = no clear statement

A: In course of different project phases, **B**: Collection of ideas, **C**: Site selection, **D**: Voluntary clean-up events

Involvement of the public in the general collection of ideas (70 %) was considerably more frequent than involvement in site selection procedures (39 %). Sites of smaller schemes tended to be selected with less public involvement. The collection of information and development of ideas has been practised through:

- Surveys
- Competitions
- Workshops (including student projects) and
- Public meetings, where projects are introduced and stakeholders can share their wishes and ideas as well as objections and concerns which can then influence planning proposals.

Public surveys are a basic tool to involve stakeholders in the planning process. Within five case studies (Don River, Pegnitz, Isar, Kaitzbach, Skerne) public surveys were conducted previous to, during or/and after the scheme implementation project. Surveys prior to implementation were used to gather community wishes and to include these concerns into the planning purposes. They were also used to uncover hidden opportunities and constraints, using the knowledge of local residents about their environment. Surveys also served to collect information on use, preferences, experiences, thoughts and wishes connected to stream, flood plain and related projects (Emscher, Isar). Depending on the overall purpose and organisational nature, either user surveys on site (Isar, Kaitzbach) or resident surveys in the vicinity of the river corridor (Kaitzbach, Pegnitz) were carried out. Two surveys were identified which have been conducted while the project was ongoing. Zurich (Albisrieder Dorfbach) asked about the acceptance within the community of daylighting. A survey at the Emscher asked about the acceptance of construction works connected to river rehabilitation and the acceptance of the river itself.

Idea competitions offer another possibility to collect ideas. Although they do not require supervision, they need much time for analysing entries and do not allow an interactive process with the public. Hence competitions are appropriate for the generation of ideas. These have been utilised on a professional or semi-professional basis, involving one or more professions like landscape architects, architects, hydraulic engineers or biologists. For the purpose of public involvement nearby, schools and even kindergartens have been involved in this form of idea collection usually supported by planning officials or involving NGOs. In the Kingmann Lake (Toronto) Scheme, citizens were asked to send in ideas in any form to planning officials. Planners collected about 300 responses which where then integrated into the first phase of planning proposals.

Workshops are an intense and interactive approach to collect ideas. They generate more discussion than competitions and have a greater influence on administrative decisions. Workshops have been conducted with various stakeholders, such as citizens, interest groups, as well as with students or pupils (Fosso della Bella Monaca, Kaitzbach). Workshops have been organised in form of weekend sessions, summer schools or multiple sessions. Either planners or representatives of NGOs usually guide workshops to ensure professional support. Outputs from workshops are displayed and handed over to responsible agencies. This process offers clear opportunities to incorporate the wishes of stakeholders into planning proposals.

Public meetings have been established as a common instrument to inform, consult and involve people in the planning process and to mediate interests of diverse stakeholders. Meetings can be either formal or informal in character. Informal meetings provide citizens with a more open and supporting atmosphere for freedom of expression. Invitations are distributed over the local media, via announcements on Internet, or via the bulk mail of residents. Some case studies established a cooperation process and used a series of meetings to ensure public involvement throughout the planning process (e.g. Quaggy). Others (Lower Rhine, Leine) only followed legal requirements and invited citizens and stakeholders only once or twice during the planning approval phase. In some case studies (Nahon, Emscher, Pegnitz) public meetings were connected with tours along the brook to increase the understanding and imagination of the stakeholders. Depending on the stage of planning, these tours were used for the collection of spontaneous ideas (Pegnitz, Kaitzbach) or to explain planning concepts. In the cases of La Chaudanne and La Saône, schemes were implemented without public participation based to wide competence of the responsible agencies.

The following examples show various kinds of public involvement in case studies.

Emscherregion
The Emschergenossenschaft (Emscher corporation) is the responsible agency for rehabilitating the Emscher and its tributaries, including the Deininghauser Bach. Much effort has been put into citizen- and stakeholder involvement. The first collection of ideas occurred through interdisciplinary competitions for professionals. For consultation and mediation work during the planning process, the corporation initiated multi-stakeholder-workshops, addressing authorities, city councils, politicians, and citizens. Brook sponsorships and school lectures such as open-air classrooms have been used to establish responsibility for the newly rehabilitated brooks.

Its members, including municipalities, communities, mining companies and industries, finance the Emscher corporation. Consequently it has to represent the interests of its members and account for its actions. A discussion process called “Emscher:Dialog” (a series of daylong meetings), was initiated to coordinate those diverse interests on a regional basis. At the first meeting the current state of planning was introduced. Additionally members were requested to summarise their expectations, visions, concerns and restrictions towards the project. As one of the last steps further actions were discussed and determined. Subsequent to this, regional meetings were held with communities, cities and diverse public planning companies. The outputs of these meetings influenced the evaluation of planning alternatives for the river enhancement.

In 2003, after 10 years of the rehabilitation programme, the Emschergenossenschaft commissioned a public telephone survey enquiring about:

- Acceptance of the Emscher programme
- Expectations (e.g. improvements for quality of life, recreational possibilities, environment, city planning, economy, flood protection)
- Perception of change initiated through the project
- Knowledge of project according to age groups

The survey gave hints where public relation management had to be increased and what perception the public had of the project.

Kaitzbach (Dresden)

In 1993 the federal government funded the research project “Development of an urban water culture”, which included the Kaitzbach case study. The main focus was put on social analysis and stakeholder involvement through surveys, project days and workshops. The research team consisted of psychologists and water management professionals. At the beginning, the psychologists conducted different surveys, adapted to previous identified stakeholder groups. Following approaches were used to obtain a comprehensive picture of stakeholder interests:

Walks along the brook were conducted to record experience on spatial relations and the spontaneous human response to the brook, with the reactions being recorded on a tape recorder. The walkers were encouraged to report everything they could observe, visions, noises, smells as well as associations, memories, wishes and judgements. A descriptive summary was prepared, sorting quotations according to topics (childhood memories, noise perception, situation of the brook, uses along the brook, knowledge of the site, and wishes, etc.).

Over three days short interviews were conducted at different places along the brook. Visitors were asked about their knowledge on the brook, likes and dislikes, uses of the brook (types of uses, times of visit). Based on the interviews people’s awareness of the brook was assessed. Problem oriented interviews were conducted with different user groups. For this purpose interview guides were formulated, which contained specific questions for certain user groups as well as common questions for all the groups.

Last but not least, a resident survey was carried out. It was conducted as a student project, with interviews of approximately. 30 minutes duration. Residents were randomly chosen within the Kaitzbach corridor (300 m width). Bulk mailing was used to inform residents. Then students equipped with a letter from the city administration carried out the interviews. Very few people did not want to participate in the survey. The surveys established an overview of actual opportunities and constraints and uncovered ideas and wishes for the brook itself as well as its environment.

Results of the surveys were used for planning purposes. Several plans for specific projects were initiated to enhance the aesthetic, ecological and hydrological aspects. The research team helped to establish contacts between diverse stakeholders such as residents and administrative departments. This helped the exchange of professional and local knowledge.

Diverse workshops, summer schools and project days involving residents, students and pupils were held for idea collection and discussions. A weekend workshop involved adjacent property owners, diverse representatives of garden allotments, firms, nature conservation initiatives and other interest groups. Outputs of this workshop as well as the outputs of the summer school have been published and presented in schools as well as to the city council (Schmidt-Lerm, Wolf 1994)

Quaggy (London)
In the Quaggy case study public consultations was carried out in two rounds: ▪ General consultations by the London Borough of Lewisham to discuss whether Chinbrook Meadows should be changed (initially regarding the river only, but, at the request of the Environment Agency, extended to park rehabilitation in general) ▪ Detailed consultations by Groundwork (local NGO) on issues of how to change the park and which features to emphasise in river rehabilitation A feasibility study followed. Carried out by Groundwork and the Environment Agency, it provided a platform for debate on the future of the park and more crucially the naturalisation proposal. After an initial stakeholder analysis, residents and park users were consulted through postal questionnaires, park surveys and invited to attend consultation events. Residents' initial fears focused on flooding and costs. However, information from the Environment Agency on flood risk and highlighting the other key benefits of the scheme gave reassurance to residents. The study concluded with an overall majority of residents in favour of naturalisation. The result were published the project partners to the implementation stage. Extensive community consultation was undertaken by Groundwork, including a well-attended public event, questionnaires and informal interviews with park users. Residents overwhelmingly voted in favour of the proposals (63 %) and fed into initial landscape designs. For idea collection a resident steering group was set up. Additional to the citizen involvement, Groundwork also promoted environmental education with local schools. The river naturalisation process provided an excellent stimulus to engage local schoolchildren in ecological issues. Groundwork worked with a number of schools to both foster environment awareness and to design a permanent outdoor classroom in the park, able to support environmental learning beyond the life of the project. (LBL 2003) The Quaggy waterway Action Group (QWAG), being co initiator of the rehabilitation project, promoted the process by offering walks in the later removed concrete channel of the river.

Don/Brick Works (Toronto)
Before the planning process for the Lower Don Valley was started the "Task Force to Bring back the Don" initiated a study of public sentiment towards the existing and future Lower Don. With the help of consulting firms, "Focus Groups Meetings" and "Public Forum Analysis" were held within the neighbourhoods of the Lower Don. Their target was to find out what were people's impression of the Don and what was their opinion concerning the preferred character of a restored Don River Valley. Nine of ten focus group meetings took place within the neighbourhoods. During these focus group meetings, after an introduction and overview on the Task Forces mandate, slides of the Don were shown and a discussion initiated. Also the participants were given the opportunity to browse aerial photographs and large-scale maps. The discussions were generally guided by ten questions focusing on the state of knowledge, the state of usage and the state of appraisal as well as the visions of citizens for the Don. The tenth meeting took place in the City Hall, with representatives of 'special interest groups' such as ornithologists, naturalists, and cyclists. Within this meeting a small plenary discussion group structure was used. After an overview of the focus group findings, participants of the public forum were broken into groups of 20 people each, discussing the concerns and goals for a future river. Findings of this final discussion, including quotations of representative statements, were summarised and integrated into the publication of the Lower Don Valley Study. Brick Works is one of many projects within the rehabilitation programme for the Lower Don and will be described here as an example of public involvement in this programme. From the initiation of the Brick works project, citizens were involved upon their request. Following the purchase of the site and before the master plan was proposed, a committee made up from the Toronto and Region Conservation Authority, and the Friends of the Valley (an influential citizen group) asked the City of Toronto community to submit ideas about what their visions for the Brickworks site might be. Three hundred submissions were sent in. These were given to the appointed design consultants, who examined the ideas for integration into the Master Plan. This plan was prepared in 1989 under the

direction of Toronto Parks and Culture Department and the Toronto Region Conservation Authority with further significant input from the public and the "Friends of the Valley". This group was involved throughout the entire development of the plan, through periodic presentations and public meetings. The Final Plan was first approved by the citizens and then reviewed by the City Council Committee that gave principal approval to the plan. At Chester Springs Marsh, another project under the Lower Don Rehabilitation Programme, representatives of the "Task Force to Bring back the Don", and a landscape architect as consultant walked the area and selected five candidate sites for wetland restoration. The purpose of this project was the demonstration of the potential of community-based ecological restoration efforts to improve the natural and public parkland value of a degraded post-urban site. Within a two-year public consultation process two sites were then selected at public meetings.

Zurich's Brooks
In Zurich the city council and by the "Bachgruppe", an interdepartmental cooperation group, have encouraged public participation for brook daylighting. The Bachgruppe called public attention to the possibility of opening up a brook, either by the city-planning department or by the wastewater and recycling department. Then citizens had an opportunity to express their wishes and ideas during subsequent discussion evenings. Property owners were personally informed. If they did not agree to the proposed course of the brook alternatives were searched and implemented. Where the brook course would be located was decided during several organised discussion rounds between neighbourhood groups (Quartiersvereine) and one to three planning officials. Discussions were based on predefined alternatives. Depending on the importance, size of the project and the number of citizensinvolved, these alternatives were visualised through three-dimensional models, which reconstructed the brook's landscape and displayed the possible future stream course.

Implementation and maintenance

Many case studies not only involved stakeholders in the planning process, but also engaged the public in the implementation of measures and the maintenance of the river site. This is especially true for the North American case studies. Public tasks included preparing signs at rivers, plantings, reintroduction of fish species, and the installation of birdhouses as well as monitoring of chemical and biological indicators of the water quality (Wandse, Don River). In several case studies, implementation of pilot sections, maintenance and monitoring was taken over by universities or public respectively private research institutes (Altenbachsystem, Náhon, Isar, Wienfluss-Auhof). Annual or bi-annual voluntary clean up events following high water periods have been facilitated in almost 50% of the case studies.

Examples of management of maintenance involving stakeholders are adopt-a-brook-groups (Wandse) and Voluntary Stream Watch Programmes (White Clay Creek). Adopt-a-brook-groups in the Wandse case are involved in improving the stream and its surroundings, watching and informing about problems and monitoring biological and chemical levels. Through the involvement of citizens, businesses and NGOs, the city administration of Wandsbek was actively supported in an effective restructuring of stream habitats. At the White Clay Creek several associations and centres run Voluntary Stream Watch Programmes. Stakeholders monitor dissolved oxygen, temperature and fish populations and are also involved in organisational work.

8.5 Stewardship and advocacy

Advocacy and stewardship for rivers can be understood as active support for river enhancement, including acts of pleading or promoting river enhancement activities and projects. This requires that citizens and responsible agencies know and understand the problems of urban rivers in order to be able to recognise sources of constraints and possible ways of improvement. Advocacy and stewardship is promoted through information and the involvement of stakeholders in projects. Moreover, this is also being done after project completion to establish a continuous awareness and to improve attitudes towards streams and their problems. Examples have been described in Chapters 8.4 and 8.5.

Table 21: Advocacy and stewardship

	Alterbachsystem	**W**ienfluss-Auhof	**W**oluwe	**N**áhon, Chrudim	**L**a Chaudanne	**L**a Saône, Lyon	**E**lbe, Hamburg Harbour	**E**mscher, Deininghauser Bach	**I**sar	**K**aitzbach	**L**eine	**P**egnitz	**W**andse	**F**osso della Bella Monaca	**T**orente Mugnone	**L**ower Rhine	**Q**uaggy	**S**kerne	**A**lbisrieder Dorfbach	**D**on, Chester Springs Marsh	**M**ud Creek	**A**nacostia, Kingman Lake	**W**hite Clay Creek	**Total YES (n = 23)**	**Total YES (%)**
A					?			x	x				x		x		x			x	x		x	**8**	**35**
B					x		x	x	x	x		x	x	x			x			x	x	x	x	**13**	**57**
C					x			x	x	x		x	x	x	?			x	x	x	x	x		**12**	**52**

x = yes, **?** = no clear statement

A: Partnerships and coalitions for river stewardship, **B**: River advocacy through continuous activities

C: River advocacy through single events

Partnerships and coalitions

Partnerships or coalitions for stewardship of rivers have been employed in about 30 % of the case studies. It seems to be a common practice to encourage brook-sponsorships (Wandse, Pegnitz, Don River) whenever a certain obligation towards a river environment needs to be created. Results obtained vary. In Hamburg-Wandsbek (Wandse) there are more than 80 existing sponsorships, involving diverse groups of stakeholders, but at the same time requiring a considerable administrative effort. A school in Nuremberg had adopted a section of the Pegnitz, but, due to maintenance reasons, this arrangement was discontinued. Other groups promoting river rehabilitation and awareness are many environmental NGOs and Agenda 21 groups, but their major field of work seem to be non-urban rivers, or river sections with a non-urban character.

Further, usually large coalitions for river stewardship and advocacy, combining groups of stakeholders, have been found to be most common in the North American case studies, though also in European case studies examples could be found (see below).

Anacostia (Washington D.C.)
In 1988, the Interstate Commission on Potomac River Basin (ICPRB) began to develop the Anacostia public outreach programme. In 1995, the District of Columbia established an Anacostia River Education Centre. One year later the Anacostia Watershed Restoration Committee's Anacostia Watershed Citizen Advisory Committee (AWCAC) was formed to improve communication and cooperation between the government and Anacostia watershed residents. Several programmes and cooperation have been established to achieve a higher level of stewardship and advocacy for the Anacostia river and the improvement programme. These are: ▪ Formation of multi-jurisdictional Community Network ▪ Anacostia River Business Coalition: an attempt to include the private business sector in the restoration work. ▪ Environmental partners: a dynamic, cooperative, pollution prevention programme between the department of environmental protection and business leaders in a variety of industries ▪ Clean water partners: voluntary information sharing initiative designed to assist businesses in preventing storm water pollution and keeping waterways clean ▪ Establishment of stream teams: programme for schools engaging teachers and students in hands on actions, experiential learning both in and out classroom ▪ Internships for undergraduate students The Anacostia River Business Coalition (ARBC) is a group of businesses in and around the District of Columbia who are concerned about the Anacostia River. ARBC focuses on education efforts to help businesses and citizens prevent pollution from toxic chemicals. It also undertakes a wide variety of projects to restore and protect the river's shoreline and tributaries while serving as a clearinghouse to link businesses with environmental resources.[5] In addition to these diverse efforts to increase public awareness, the public has been highly involved in the development of a suite of restoration indicators. Those have been integrated into the detailed annual appraisal of progress on watershed restoration, which are distributed to NGO's, business partners and are available to citizens via the internet or publishing agencies.

Isar (Munich)
Almost over night watchful citizens of Munich established the ISAR Alliance as a reaction to an application by a power plant to extract more cooling water from the Isar river. The alliance united ornithologist, angler, canoeists, hunters, the Isar Valley Interest Group and the German Alpine Cooperation with together more than 0,5 million members. The organisation has promoted an informal involvement in the development of the Isar Plan, the rehabilitation Programme for the Isar. It is due to their commitment, that ecological enhancement became possible.

Wandse (Hamburg)
The idea to rehabilitate the Wandse as a trout habitat has been supported by citizens, interest groups and a public administrator at the Bezirksamt Wandsbek. Interested groups had been contacted before the official start of the project. A member of an ecological NGO (BUND) is the project manager. A group of young anglers within the German Anglers Association (VDSF) initiated first trout breeding experiments in order to check the chances of the project's success. Currently approximately 80 adopt-a-brook-groups with a work force of 800 individuals are involved in analysing, developing, implementing and maintaining the Wandse. The groups themselves decide how much responsibility they want to bear. Involved stakeholders include not only citizens, but companies, interest groups and schools.

[5] http://www.potomacriver.org/arbc/arbc.htm

River advocacy

Activities for advocacy and stewardship include newsletters, guided tours, exhibitions, voluntary monitoring, involvement of schools etc. These activities have been described in Chapters 8.4 and 8.5.

Single events for advocacy of rivers and of river rehabilitation projects have been conducted with different purposes. Celebrations have taken place as the starting point of the implementation (Skerne), to inaugurate completed schemes (Skerne, Don, Mud Creek) or to cretae an overall awareness of the rivers (Alterbachsystem). Further examples of activities to increase of awareness are described below.

Kaitzbach (Dresden)
Within the Kaitzbach project a change of public awareness towards the Kaitzbach has been seen as basis for an enhanced environment and responsible water use. Hence, an idea competition to increase public awareness was initiated. The following ideas were developed in this competition: ▪ A game of dice - knowledge about the brook and its environment is transported via a game - the game board displays real pathways and problems along the brook ▪ Establishment of sculptures and installations along covered section of the brook ▪ A poster series, which display places connected to water, but missing the water - visually easy to understand Temporary art installations (Art Project "Mesmosyne") and performances along the Kaitzbach took place from 1994 to 1997. Permanent installations were started in 1998.

Emscherregion
The Emscher corporation will employ an Emscher-Narrator for two years (2003-2005). The narrator is an actor, who will visit schools, festivals, market squares and tell old storeys of the Emscher or its tributaries, mixed with the new concepts of the project. The narrator will also ask people to tell their stories and experiences with the river. The person will collect these stories and incorporate them in future performances. Later the experience of these two years will be summarised in an exhibition and may become part of a theatre play.

8.6 Monitoring social impact

Monitoring social impacts of river rehabilitation has not been a focus of the available case studies. Surveys conducted after the implementation of a scheme have been mentioned in some case studies, but could not be obtained for analysis. Despite these findings, indicators for a socially successful rehabilitation may be found e.g. in an increased numbers of visitors, increased usability and above all an increased awareness and participation in public projects (see Chapters 6.2. and 9).

Social awareness has been monitored in the course of stakeholder involvement in the Anacostia River and Don River programmes and were included in progress reports (e.g. number of brook sponsorships or number of involved stakeholders for awareness and stewardship). In Zurich (Albisrieder Dorfbach) it was found that neighbourhood groups who had been involved in a Brook-Daylighting-Project had also been motivated to engage in other projects. They started transforming parking lots into green areas, building playgrounds with fruit trees and using sheep to maintain the grassland areas of selected neighbourhoods. An approach to monitor social impact was developed during the Kaitzbach project (see below).

Kaitzbach (Dresden)
Prior to the start of the project, the press and other publications were monitored and analysed, looking for overall awareness of urban waters and especially for awareness of the Kaitzbach. After the project had been progressing for more than a year, the social impact was evaluated in terms of: ▪ Established social networks (number of contacts to other stakeholders) ▪ How many projects had been developed ▪ How appreciation of the Kaitzbach had changed The findings displayed an unexpected consensus on the daylighting of rivers, but also revealed different motivations among the stakeholders: ▪ Residents and interest groups were motivated by the potential of ecological and urban enhancement within the city. ▪ Sewage treatment companies intended to reduce the costs for sewage treatment. Representatives from city departments, planning offices, universities, citizen initiatives, youth organisations, politicians, artists and neighbours were the most active. The overall project review stated, that: ▪ An intermediate organisation (in this case the research team), which promoted the connection of different levels and areas of activity (social spheres, politics and actions) increased the potential of success (as was also true for Albisrieder Dorfbach) ▪ Political and institutional will has to be high to exceed the minimum public involvement mandated by law

9 Performance control and indicators of success

Monitoring, evaluation and adaptive management are essential components for the successful implementation of any river rehabilitation project. It is even more important for the rehabilitation of urban waters, due to the often enormous complexity of urban settings. To evaluate success of any measure requires monitoring which in turn needs appropriate indicators. This includes the assessment of relevant parameters before works start, the monitoring during construction and an evaluation, once the project is completed. Considering the initial conditions, the process of conducting performance control needs as a first step the definition of a 'target state', as related to goals and objectives of the project. This 'target state' needs to be made measurable by setting thresholds against which measured data can be evaluated. Thus, already during implementation, the monitoring and evaluation may become important to enable stakeholders to react to impacts through adaptation either of the measures or of the targets.

Post-implementation appraisal of river rehabilitation projects is becoming increasingly important, particularly because of its political relevance. Many rivers have been restored at a substantial cost during the last years and decades. As shown in Chapter 4 financing of river rehabilitation is usually entirely based on tax revenues. Nevertheless, a UK study found that of almost 100 river rehabilitation projects only five had been subject to reported post-implementation appraisal. However, with a raising awareness for river related issues, as well as the development of concrete rehabilitation goals, it becomes increasingly important to measure the effects of river rehabilitation. It is a vital basis for the development of effective measures for river rehabilitation in future. Consequently it is important to prove that public taxes have been spent wisely and have been goal-oriented. It is also important to ensure the political and public acceptance of such projects, not only today but also for the future.

Indicators for urban river rehabilitation can be used for three major purposes:

1. To communicate the problems of a site, enabling the general public and its decision makers to realise the gravity of existing conditions

2. To set goals, objectives and thresholds against which conditions can be measured

3. To communicate results of an urban river rehabilitation effort

Indicators of success need, therefore, to be linked to proposed objectives. They also need to be capable of being communicated. For this purpose indicators need to contain considerable information for experts and be self-explanatory for the public. This applies to environmental as well as economic, social and aesthetical indicators. Last, but not least, indicators of success are important as a powerful tool to raise public awareness of urban river issues and to show the effectiveness of efforts made, as well as to promote further rehabilitation efforts.

9.1 Definitions

For the work with indicators it is important to define the meanings of the terms 'parameter', 'indicator' and 'index'. All three are hierarchical elements of an indicator system and, therefore, are relevant in the process of indicator development. According OECD (1993, p. 6) these elements are defined as following:

Parameter: A property that is measured or observed. (in Figure 49 'parameter' is represented through 'primary data')

Indicator: A parameter or value derived from a parameter; which points to, provides information about, or describes the state of a phenomenon, environment, or area with a significance extending beyond that directly associated with a parameter value.

An indicator must *reflect changes* over a period of time linked to the problem, it must be reliable and *reproducible* and, whenever possible, it should be *calibrated* in the same terms as the policy goals or targets linked to it (cf. Hammond 1995, p. 11)

An indicator is a *quantitative measure* of an impact without stating whether the change itself is positive or negative (Schneider 1995).

Indicators are representative *latent variables or characters* that are used in the case of missing meta data or to simplify complex data sets (*Hübler* & *Otto-Zimmermann 1989*).

Index: A set of aggregated or weighted parameters or indicators.

"The key point to be made about an indicator is that it is a measure that has significance that is broader than the measure itself; that is, the measure represents a much wider issue, condition, phenomenon or circumstance than what is directly measured" (EPA 1996, p. 5). The three terms are also connected with each other in a sort of hierarchy of information content. Via aggregation of data (measured parameters) a more complex statement can be made about a state of the property of interest. At the same time aggregation of obtained information is needed to make it more communicable to the non-expert world. Figure 49 shows the dependency of the levels in the hierarchy of an indicator system.

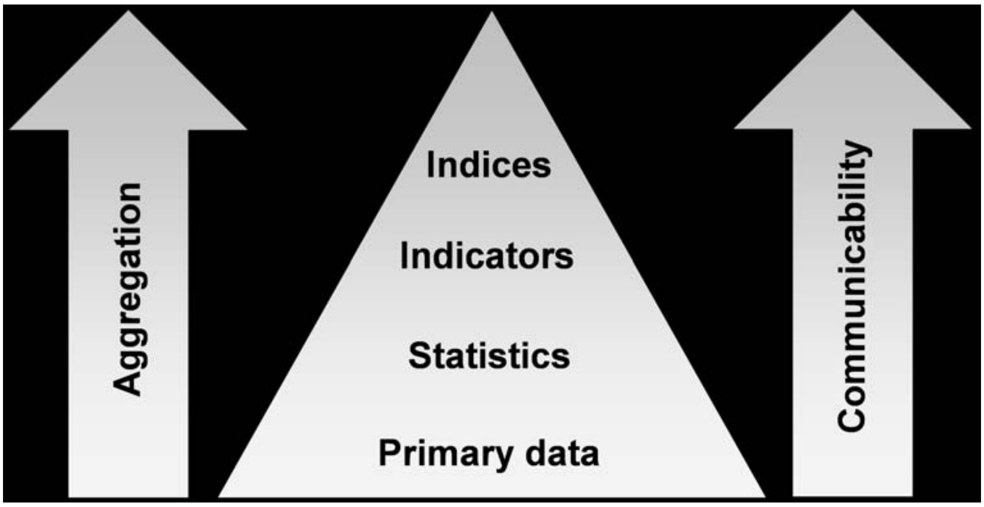


Figure 49: The Information pyramid of an indicator system (based on World Bank 2002, p. 17)

The presented definitions unveil that their application remains restricted to quantifiable aspects. For this reason a further term may be introduced to cover aspects the quantification of which has not yet been proven. The term **'criteria'** may serve as the counterpart to what above was named 'indicator', but which is not comparably measurable. This will apply first of all to issues where measurement based on qualitative information has to be applied.

9.2 Performance control as practised

It has been mentioned above that in only a few case studies were systematic monitoring and post implementation appraisal carried out. All together the extent of monitoring and the quantity and quality achieved differed a lot depending on the project size, project design and the availability of financial resources.

In most case studies, at least some parameters were considered in the process of rehabilitation. Some of those appeared regularly, some only occasionally. Most often biological indicators including fauna and flora as well as water quality aspects where monitored. Assessments of societal factors including social, aesthetical and economic aspects were rarely carried out. Below parameters, indicators, indexes and methods as obtained from the case studies are summarised.

Ecological monitoring

In terms of ecological monitoring and site appraisal the following parameters and indicators have been applied in the case studies.

Hydrology and hydromorphology

- Hydrological regime (incl. mean discharge and extremes)
- Bank full flow conditions
- Sediment balance
- Bed shear force
- Stream morphology
- Cross section

Water quality

- Chemical
- Biological
- Physico-chemical (e.g. automated dissolved oxygen)
- Different groups of pollutants

Vegetation

- invasives
- shrubs
- trees
- perennials

Fauna

- Aviofauna
- Ichtiofauna
- Invertebrates

- Mammals
- Amphibians
- Sediment concentrations
- Nutrient concentrations

Other

- Soil pollution (heavy metals)
- Potential for re-colonisation of river section
- Land use distribution (e.g. percentage of impervious area within the basin)

In the evaluation of biological parameters, aspects of species richness, abundance and conservation value played an important role. With reference to aspects of hydrology and water quality, various typical measured values where used, though in different countries different measurement methods and thresholds were applied. Here the standardised monitoring requirements under the WFD will in future promote the easier comparison of measurements in terms of water quality and biological parameters. Only one case study was reported to have followed the standards of the WFD: in the Emscher case WFD standards for monitoring were integrated into the design of the rehabilitation scheme.

Indexes used included the Europe wide applied 'Saprobic index' and the Italian Extended Biotic Index (EBI)

The following approaches and methods where applied in the process of monitoring in the case studies:

- Reference conditions
- Hydrologic and hydraulic modelling
- Geomorphological modelling
- Rosgen morphological stream classification
- Stream habitat structure mapping (Strukturguetekartierung, D)
- EHS (Ecologische Hoofdstructuur, NL)
- Biological inventory
- Breeding experiment of brown trout fry
- Test section monitoring
- Environmental Impact Assessment
- Photo documentation of changes

Social and economic aspects

Only rarely have the social or economic aspects been explicitly considered for appraisal in the context of urban river rehabilitation. An extensive public perception study (see Chapter 8) was carried out for Skerne River and Kaitzbach. In addition, in the case of the Skerne River an economic appraisal was conducted. Little was obtained from other case studies in this respect. The following aspects were considered:

Social

- Public perception of rivers, stewardship and advocacy
- Public Acceptance
- Public awareness and stewardship
- Ownership
- Stakeholder network
- Built structure
- Aesthetics
- Recreational value

Economic

- Economic appraisal
- Cost measurement

Methods, applied for the assessment of social, aesthetic and economic aspects were:

- Stakeholder analysis
- User surveys
- River Landscape assessment
- Photo documentation and
- Cost-benefit- analysis

Other aspects

A number of further aspects where considered in site appraisals:

- Historical conditions
- Flood potential
- Watershed problems

The listed issues have been targeted before, during or after project implementation. In total only few of these aspects were considered by more than one case study. Often only single measurements were carried out, which were not necessarily representative.

One reason why evaluations of relevant parameters are not conducted on a regular basis is the cost of such measurements. The more complex is the set of criteria, the more costly the monitoring may become. However, monitoring costs also depend on the type of parameters that are used.

Standard parameters measured by statewide programmes may be provided from central databases. Such monitoring programmes exist in most European countries and contain more or less detailed water quality parameters and hydromorphological conditions of waters. Unfortunately the scale of such central monitoring may be substantially different from that required for discrete rehabilitation sections. The grid for water quality measurement often is too wide and usually not all the parameters relevant to a rehabilitation project are covered.

General assessment tools for river habitat, such as the German tool for mapping stream related structures (Gewässerstrukturgütekartierung, LAWA 2000), often are applied on levels that do not discriminate enough for discrete river sections. Thus additional measurements are often needed to achieve representative results for short urban river rehabilitation sections.

Comprehensive monitoring could be found in two of the North American case studies. The Don and Anacostia case studies both combine a large variety of relevant issues and ecological as well as societal parameters were used in each project. The monitoring approaches of these two rehabilitation projects are summarised below to give a concise view on what has been done.

Don River (Toronto)

The entire watershed is considered by the Don River monitoring programme. It was initiated by the Don Watershed Task Force and put forth in their challenging and internationally renowned "40 Steps to a New Don" (TRCA 1994). The monitoring programme is carried out and financed by the city and repeated every three years.

The monitoring programme considers the ecological state of the water body and the surrounding habitats as well as social aspects. Indicators describe the quantity and quality of ecological and social aspects, and the state of measures applied to enhance the water body. There are a total of 18 indicators, accompanied by sets of targets or specific aims. The following tables summarise the contents of the "Don Watershed Report Card 2000" (DWRG 2000). They are headed by the following themes: 'caring for water', 'caring for nature', 'caring for community', 'protect what is healthy', 'regenerate, what is degraded', and 'take responsibility for the Don'.

Table A: Caring for water

Parameter	*Indicator*	*Description of measurement*
Quantity	1. Flow Pattern	Discharge, peak flows.
Quality	2. Water Quality -Human Use	Parameters include, but are not limited to, bacterial count (faecal coliforms, E.coli), phosphorus, and nitrite, copper, zinc, suspended solids, ph, temperature, dissolved oxygen, ammonia, copper.
	3. Water Quality - Aquatic Habitats	Wet weather sampling of total suspended solids, aquatic invertebrates studies, young-of the-year fish monitoring, identification of persistent toxins.
	4. Storm- water Management	Percentage of watershed in quantity and quality control.

Table B: Caring for nature

Parameter
Indicator
Description of measurement

Quantity and Quality of Habitats
5. Woodlands
Percentage of watershed in woodland.
Goal: 30-25% of woodland cover within a watershed is threshold for a healthy watershed.

6. Wetlands
Percentage of area within watershed (Target 0.5 % of watershed).

7. Meadows
Percentage of area within watershed.

8. Riparian Habitats
Percentage of riverbank with aquatic vegetation.

9. Frogs

Baseline data to be developed increase number and diversity.

10. Fish
Number of removed barriers to fish migration.

Table C: Caring for community

Parameter
Indicator
Description of measurement

Appraisal and Actions
11. Public Understanding and Support
Percentage of watershed inhabitants expressing knowledge of and expectations for the river.

12. Classroom Education
Percentage of elementary, junior high and high school classes in Toronto visiting the Don.

13. Responsible Use and Enjoyment
Number of users.

Table D: Protect what is healthy and regenerate what is degraded

Parameter
Indicator
Description of measurement

Nature areas
14. Protect Natural Areas
Percentage of natural areas within watershed in public ownership.

15. Regeneration Projects
Number of regeneration projects. Objective: To increase the number of regeneration projects undertaken in a three-year period from 100 to 200.

Table E: Take responsibility for the don river

Parameter
Indicator
Description of measurement

Personal
16. Personal Stewardship
Percentage of watershed residents that volunteer time or funding.

Business
17. Business and Institutional Stewardship
Number of businesses and institutions signing an agreement of stewardship.

Municipal
18. Municipal Stewardship
Adoption and enforcement of water friendly policies, controls, and practices (e.g. reduction of salt, pesticides, fertiliser, topsoil preservation, sediment control, fill, groundwater protection, native plants).

These indicators were evaluated using following approach to evaluation: Each indicator was presented within the so-called report card under the following questions:

- Where were we at the last monitoring?
- What were the targets?
- Where are we now at this monitoring?
- What is the development trend?
- Where do we want to be?
- How do we get there?
- What measures are necessary to be reaching targets?

The approach did not use a solely quantitative approach, but rather used descriptions augmented by numbers. This approach ensured an understandable presentation for the public and was made available via the Internet (cf. DWRG 2000).

Anacostia (Washington D.C.)

"Anacostia Restoration Indicators and Target Project (I & T Project)"

In 1999 an agreement was reaffirmed and a new provision added to develop a set of specific, long-term restoration indicators and targets under public participation. Six fundamental goals were defined to be achieved by the year 2010. A set of 31 "Technical Indicators" and 19 "Public Awareness/ Stewardship Indicators" were established for the year 2001.

A numerically based scoring system (e.g. 0-100 points total with associated verbal ranking categories) was employed to provide a more systematic and consistent method for reporting.

Draft versions of a restoration progress summary sheet with a subset of 16 so-called "Leading Indicators" and a more detailed companion 'Report Card' have been developed to facilitate public understanding and dialogue.

Leading indicators:

Goal 1: Reduce pollutant loads

- Total suspended solids
- Combined sewer overflows
- Faecal coliform concentration/ bacterial contamination- instream concentrations
- Dissolved oxygen
- Trash index and quantity of trash removed

Goal 2: Restore ecological integrity

- Deformities, Erosions, Lesions, Tumors (DELTs)
- Macroinvertebrate community health
- Health of resident fish community
- Stream miles restored
- Percent of developed land in the watershed with storm water controls

Goal 3: Improve fish passage

- Percent historical anadromous fish spawning range open

Goal 4: Increase wetland acreage

- Created/ restored tidal wetland acreage
- Created/ restored non-tidal wetlands

Goal 5: Expand forest coverage

- Miles of created riparian forest

Goal 6: Increase public and private participation

- Number of school activities
- Number of active "Friends of" groups

Anacostia stakeholders receive a detailed annual appraisal of watershed restoration progress and a summary sheet with dashboard-like gauges intended to convey annual and overall restoration progress 'at a glance' for each of the six goals.

Monitoring programme

The rehabilitation project established frameworks of watershed-wide monitoring and restoration reporting to elected officials and the public. Prior to the start of restoration work, aquatic biota and water quality were evaluated. The results established a pre-restoration baseline data set and were utilised during the planning process. Vegetation monitoring has been carried out over a 5-year period in order to document the development and evolution of reconstructed wetlands.

Monitoring results have led to several adaptive management decisions, e.g. replanting less palatable wetland species, measures to limit invasive species such as Phragmites, installing of trash barriers. Other research and monitoring efforts included studies of the accumulation of toxins in fish, invertebrates and sediment, fish, plant, reptile, amphibian and bird surveys.

(DEP, MWCG,2001)

9.3 Towards indicators of success for urban river rehabilitation

Beside financial restrictions, the partial lack of appropriate indicators may be an important barrier to efforts to measure the success of urban river rehabilitation schemes. 'Appropriate' in this context applies to measurability, expressivity and communicability (see above). In the past, as proved by the case studies, monitoring of river rehabilitation was limited in most cases to the measurements of ecological parameters. However, although being a vital part of the success of a rehabilitation scheme, ecological aspects alone do not cover all urban aspects. Particularly in urban areas, social, aesthetic and economic aspects must also be considered when dealing with the impact of urban river rehabilitation.

As a basis for the present study, the enquiry considered a variety of societal aspects that may lead to the development of indicators to cover some of these missing aspects. A research project, dedicated to the development of indicators of success for urban river rehabilitation schemes, will be conducted under the URBEM Project in 2004-2005 by the

Leibniz Institute of Ecological and Regional Development and the Dresden University of Technology.

Ecological aspects are already well covered by the indicators proposed by the European Water Framework Directive. Once threshold values for the quality classes of the proposed indicators are defined a standardised monitoring system will be available to all stakeholders. These indicators are already defined and can be used in the future. The indicators introduced by the WFD are not only well developed but also provide European-wide targets and with this a clear scope for future river rehabilitation. A few more indicators may be introduced by the announced study to cover some additional specific ecological aspects.

Criteria for social appraisal have been partly presented in Chapter 6. According to this the following indicator groups may be used:

- Aspects of social and cultural infrastructure (e.g. uses related to water body and river corridor)
- Aspects of social and aesthetic perception and experience of riverscape
- Overall acceptance of urban river rehabilitation sites (e.g. site attendance by individuals and groups)
- stewardship and advocacy of river rehabilitation

Also economic criteria have been presented in Chapters 3 and 6:

- Total and relative costs of urban water course rehabilitation (e.g. cost per meter)
- Economic well being (e.g. property value, housing costs or investment activities)

With the development of a comprehensive set of indicators for the measurement of the success of urban river rehabilitation schemes an important gap will be closed and a basis for further development of river rehabilitation will be established.

10 Summary

Within the European research project "Urban River Basin Enhancement Methods" (URBEM) a study of existing urban river rehabilitation schemes has been carried out. The overall aim of this study is to provide an overview of the state of the art of urban river rehabilitation in Europe including experiences from countries of other continents. The study has focused on the following topics:

- Planning process
- rehabilitation techniques
- ecological, social and economic impacts
- aesthetic evaluation
- social appraisal and stakeholder involvement
- performance control

An initial survey identified about 50 schemes that had the potential to act as case studies. From these 23 case studies were selected and a questionnaire was completed by each case study.. The selection was based on schemes that were (i) dedicated to surface water bodies or their sections in an urban or sub-urban setting, (ii) based on the aim to rehabilitate the water body and (iii) had already been completed. The selected cases represent nine European countries as well as the U.S. and Canada.

Nearly all of the case studies had the aim of ecological improvement. Other reasons for rehabilitation that were mentioned included: flood control, amenity value and recreation, visual enhancement as well as urban upgrading in general. To achieve ecological improvement the most important issues that were mentioned were: stream morphology, water quality, hydrology and hydraulics. Canalisation and spatial limitations are the most frequent constraints for urban rivers. The size of the water bodies covered by the case studies varied between ones less than a metre wide to others more than one hundred metres wide with a majority having a width of between one and twenty-five metres. The length of the rehabilitated urban river reach ranged from less than one hundred metres to nine kilometres. The total project costs ranged from low budget projects costing considerably less than 50,000 Euro up to projects with costs of 27 million for the river works.

The detailed investigation regarding the realisation of the schemes show that rehabilitation projects were mostly initiated by city councils, about half of them in conjunction with citizen's groups. The *planning and implementation process* started with the initiation of a project, involving the city council and a political process to assure the allocation of the necessary funds. The site selection in most cases was based on existing knowledge and usually only one option was considered. In more than eighty percent of the cases the planning process was enabled or backed by legislation, in contrast to only one third which were regulated by a project related form of legislation. Financing in three-quarters of the schemes was based on multi budget sources. In one third, private sponsorship played a role. Between the initiation, planning and implementation in most of the investigated schemes several years passed by.

Rehabilitation techniques were investigated with respect to improving the hydrology and hydrodynamics, stream morphology and connectivity, water quality, aquatic and riparian biodiversity as well as features for public health and safety. Hydrologically less disturbed discharge regimes and sediment balances were a rehabilitation objective in half of the cases. Improvement of base flow through storm water infiltration was attempted in about one quarter of the case studies. Concerning stream morphology and connectivity, measures have been identified referring to instream morphology, flood plains and stream continuity. Especially important were measures aimed at the rehabilitation of stream alignment and gradient, channel side slopes and bed-forms, the integration of flood plains and the restoration of biological continuity. Measures aimed at continuity followed the restoration of river gradients and the removal or bypassing of flow structures and barriers to ecological migration. In terms of lateral connectivity of the channel, side slopes, the removal of 'hard' and applying 'soft' stream bank protection played a central role in about eighty percent of the cases. Thereby it became obvious that soil-bioengineering techniques that originate from Central Europe have now found international acceptance. In half of the cases, cross-sectional depth variations were re-established, hard bed lining was removed and river bed sediments were cleaned or replaced.

The impact on water quality of large treatment plants was excluded from the study but some schemes related to storm water storage and treatment as well as decentralised biological sewage treatment.. Restoration was the riparian vegetation was an objective in ninety percent of the cases, while restoration of aquatic vegetation was an objective in fifty percent of the cases. Additionally in one third of the cases, works were carried out to enhance public health and safety either through scheme design or by construction e.g. for flood protection and prevention of accidents along riversides are identified.

The impact of river rehabilitation and enhancement projects with regard to ecological, social and aesthetic improvements were considerable. Referring to the ecological impacts, about half of the cases reached a moderate status of different components, one-third reached a good status. This result could be interpreted in different ways. First of all local rehabilitation schemes cannot deal with the impacts on catchment scale. Moreover, within many projects aims expressed in terms of the WFD were neither formulated nor monitored. Therefore, the implementation of the directive could be expected to strengthen the attainment of good ecological status. In many rehabilitation projects the improvement of the suitability for active and passive recreation as well as educational aspects played an important role. This underlines the role of urban water courses for open space uses.

Aesthetic evaluation played a role in many of the schemes, whereas the application of formal assessment methods was rare. Visual and spatial aspects and measures to enhance aesthetic experience were named as components of implemented projects by two-thirds of the case study participants. Primarily vision but also space, more seldom smell and sound as well as emotional responses were considered in rehabilitation schemes. In contrast, the use of aesthetic evaluation methods was reported from only approximately every fifth case. This ratio may be seen as a result of a missing common comprehension of aesthetics in urban river enhancement as well as in landscape assessment in general. The methods applied included expert assessment and surveys.

Social appraisal and public involvement was found to be an important issue main task of rehabilitation schemes. This includes the identification and information of stakeholders and their involvement, as well as reach-out programmes for advocacy and stewardship to initiate and maintain projects. Public participation was practised in more than eighty percent of the case studies. A surprising two-third of the schemes was found to use the Internet, radio and television as media to communicate their efforts. Thus, participatory democracy, involving diverse stakeholders seem to be increasingly appreciated.

Indicators of success have been applied to various degrees and with different quality and quantity, depending on project objectives, available financial resources and project size. Monitoring according to the WFD has only taken place in one case study. One reason why post implementation evaluations have not been made more frequently is the costs involved. Monitoring costs depend on the type of parameters used. Standardised parameters measured in normal monitoring programmes deliver data but may not be at an appropriate scale for rehabilitation programmes. More and more detailed measurements are necessary to assess rehabilitation schemes. Only exceptionally pre-improvement assessments had been carried out. Under these conditions a post-improvement appraisal can enable a comparison and thus an assessment of success. It is most important that monitoring that proves the success of projects is made public. Only then can the value of stream enhancement be demonstrated, proving to the public that tax-payers money has been spent wisely and thereby increasing acceptance and promoting further river rehabilitation.

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Mrs. Komárkova	Chrudim city council, board of green spaces

FRANCE

La Chaudanne, Grézieu la Varenne (Rhône region)

Mr. Pascal Breil	Agricultural and Environmental Engineering Research (Cemagref)
Mr. Franck Ruffin	Syndicat Intercommunal d'Assainissement de la Haute Vallée de l'Yzeron (SIAHVY) – Inter-municipal partnership of cenvenience for waste water purification in the upper Yzeron river valley)

Mr. Stéphane Guérin	Syndicat d'Aménagement et de Gestion de l'Yzeron – Cooperation board for the Management of the Yzeron river basin (SAGYRC)

La Saône, Lyon

Ms. Sylvia Prost	Conseil général du Rhône (section CATER 69 - Rhône Insertion Environnement) – Regional Council of the Rhône department (Environment management section)

GERMANY

Elbe Harbour Facilities, Hamburg

Ms. Dorothea Derksen:	Behörde für Umwelt und Gesundheit, Hamburg (City board for Environment and Health)

Emscher, Deininghauser Bach, Castrop-Rauxel (Emscherregion)

Mr. Rudolf Hurck	Emschergenossenschaft, Department of River Basin Management
Ms. Semrau	Emschergenossenschaft, Department of River Basin Management

Isar, Munich

Mr. Walter Binder	Bayrisches Landesamt für Wasserwirtschaft
Mr. Alex Temeschinko	Wasserwirtschaftsamt München, Abteilung Isar, Gewässerentwicklung und Öffentlichkeitsarbeit
Prof. Werner Nohl	Landschaftswerkstatt, Studio for Landscape and Open Space Development

Kaitzbach, Dresden

Mr. Frank Frenzel	City Council of Dresden, Department of Environment
Mr. Andreas Stowasser	Technical University of Dresden, Institute of Architecture and Landscape Architecture, Department of Landscape Construction

Leine, Hannover

Ms. Martina Dams	Landeshauptstadt Hannover, Fachbereich Umwelt und Stadtgrün - Hanover city council, board for urban green spaces

Pegnitz, Nuremberg

Mr. Klaus Winkelmair:	Department for Water Management, Nuremberg

Wandse, Wandsbek

Dr. Ludwig Tent:	Administration of the Borough Wandsbek, Hamburg; Division for Environmental Protection

ITALY

Fosso della Bella Monaca Ditch, Rome

Ms. Anna Caspari	Waterdesign Rome
Dr. Paolo Anella	Waterdesign Rome

Torrente Mugnone, Florence

Dr. Pietro Rubellini:	City of Florence, Servizio Geologico

The NETHERLANDS

Rhine, Arnhem

Mr. Iede Block :	Rijkswaterstaat, Head office Oost-Nederland

UNITED KINGDOM

Quaggy River, Chinbrook Meadows (LB Lewisham), London

Ms. Julie Baxter	Environment Agency Thames Region South East Area
Mr. Trevor Odell	Environment Agency Thames Region South East Area
Mr. David Webb	Environment Agency Thames Region South East Area
Mr. Matthew Blum	Quaggy River Action Group (QUAG)
Mr. Conrad Young	London Borough of Lewisham

Skerne River, Darlington

Mr. Martin Janes	River Restoration Centre (RRC)
Ms. Liz Chalk	Environment Agency Northeast, York
Mr. George Brook	Darlington City Council

SWITZERLAND

Albsrieder Dorfbach, Zurich

Mr. Reinhard Buchli	ERZ Entsorgung & Recycling Zürich

Mr. Markus Antenner	ERZ Entsorgung & Recycling Zürich

North America

CANADA

Don, Toronto

Ms. Bookbinder:	Task Force to Bring Back the Don

Mud Creek, Toronto

Mr. Michael Hough:	Envision the Hough Group, City of Toronto

U.S.A

Anacostia, Kingman Lake, Washington D.C.

Mr. Peter J. Hill	DC Department of Health, Environmental Health Administration, Watershed Protection Division
Mr. Uwe Steven Brandes:	Anacostia Waterfront Initiative, Washington
Mr. Cameron Wiegand	DC Department of Health, Environmental Health Administration, Watershed Protection Division
Dr. Edward U. Graham	Metropolitan Washington Council of Government, Water Resources Program

White Clay Creek, Wilmington, Delaware

Ms. Sara L. Wozniak:	University of Delaware, Institute for Public Administration, Water Resource Agency of New Castle County
Mr. Gerald J. Kauffman	University of Delaware, Institute for Public Administration, Water Resource Agency of New Castle County
Mr. Bernhard Dworsky	University of Delaware, Institute for Public Administration, Water Resource Agency of New Castle County

13 Annexes

Annex 1 Data enquiry form

Annex 2 Description of techniques

Annex 1 Data enquiry form

Urban River Basin Enhancement Methods (URBEM)
Case Studies of Existing Successful River Enhancement Projects
(Ax) Additional Information Concerning '(A) Ecological and Chemical State'

Name of river :	**concerned river section (**km 'x' to 'y')**:**
Name of site and project:	
Time of revitalization:	
Responsible (project) agencies: (Address, Phone, Mail, contact person)	
Water body category (according to WFD 'A' for 'river' / B for 'artificial and heavily modified surface water body') :	
Person filling out form: (Name, Phone, Agency)	

I Biology (please name species and population characteristics before and after implementation)

		information on population (abundance, stability (self-sustaining), dynamics etc.)	
		before implementation	**after implementation**
1	**Ichtyofauna**		
	specie x … (please fill in, add as many lines as necessary)		
2	**Invertibrades**		
	specie x … (please fill in, add as many lines as necessary)		
3	**Riparian Vegetation**		
	specie x … (please fill in, add as many lines as necessary)		
4	**Submerged Vegetation**		
	specie x … (please fill in, add as many lines as necessary)		
5	**Avifauna**		
	specie x … (please fill in, add as many lines as necessary)		

II Hydrology							
	value						comments
	min.	max.	HQ5	HQ50	HQ100	HQ200	
a) discharge **before** implementation (m3/s)							
b) discharge **after** implementation (m3/s)							
c) area (onsite) subjected to flooding **before** implementation (m2)							
d) area (onsite) subjected to flooding **after** implementation (m2)							

I Hazardous Substances (WFD)			
please fill in if augmented or exceeded	**value measured**	**limit value**	**comments**
specific synthetic pollutants			
…			
…			
add further lines if necessary			
specific non-synthetic pollutants			
…			
add further lines if necessary			

Urban River Basin Enhancement Methods (URBEM)
Case Studies of Existing Successful River Enhancement Projects
(A) Ecological and Chemical State

Name of river : **concerned river section** (km 'x' to 'y'):

Name of site and project:

Time of revitalization:

Responsible (project) agencies: (Address, Phone, Mail, contact person)

Water body category (according to WFD 'A' for 'river' / B for 'artificial and heavily modified surface water body')

Person filling out form: (Name, Phone, Agency)

AA State of water body (according Water Framework Directive) before and after implementation

	parameter / evaluation scale	state of water body before rehabilitation (reference date: ………..)					state of water body after rehabilitation (reference date: ………..)					comments (e.g. delivered annexes etc.)
		high	good	mod.	poor	bad	high	good	mod.	poor	bad	
	Ecological and Chemical State											
I	**Ecological State**											
1	**Biological State**											
	a) phytoplankton											
	b) macrophytes and phytobenthos											
	c) benthic invertebrate fauna											
	d) fish fauna											
2	**Hydro-morphology**											
	a) hydrological regime											
	b) river continuity											
	c) morphological conditions											
3	**Chemical and Physico-chemical Components**											
	a) general conditions											
	b) specific synthetic conditions											
	c) specific non-synthetic pollutants											
II	**Chemical State**											
	see also (Ax)-additional											

AB	**State of water body (according Directive on bathing water quality 76/160/EEC) before and after implementation**									
evaluation scale / parameter		state before rehabilitation (reference date: ………...)				state after rehabilitation (reference date: ………...)				comments (e.g. delivered annexes etc.)
		1	2	3	x	1	2	3	x	
	Bathing Quality									
I	**Microbiological Parameters**									
II	**Physico-chemical Parameters**									
III	**other Substances regarded as Indicators of Pollution**									
1 = below G-value; 2 = below I-value; 3 = I-value exceeded: no bathing possible; x = no data available										

Urban River Basin Enhancement Methods (URBEM)

Case Studies of Existing Successful River Enhancement Projects

(B) Social and Economic Well-being

Name of river : | **concerned river section** (km 'x' to 'y'):

Name of site and project:

Time of revitalization:

Responsible (project) agencies: (Address, Phone, Mail, contact person)

Water body category (according to WFD 'A' for 'river' / B for 'artificial and heavily modified surface water body') :

Person filling out form: (Name, Phone, Agency)

	state classification / parameter (of state)	descriptions, explanations for state classification delivered annexes	Parameter irrelevant	state before revitalization* (reference date: ………..)			state after revitalization* (reference date: ………..)		
				+	+/-	-	+	+/-	-
* classification of the parameter on the left (if not individually defined): + above-average / +/- average / - below average ('average' concerned to the local situation) if there has been a shift from the state before and after rehabilitation that can hardly be reflected by this classification please specify verbally									
BA	**Access / Mobility Infrastructure**								
I	**Moving towards River (accessibility)**								
	a) accessibility by private motor vehicles								
	b) accessibility through public transportation								
	c) accessibility by soft modes of transport such as pedestrians, bikers, rollerbladers etc.								
	d) accessibility to rehabilitated site for people with disabilities								
	other, please add and describe								
II	**Moving along River**								
	a) moving along river by private motor vehicles or public transportation								
	b) moving along the river by soft modes (e.g. walking, biking)								
	c) moving along the river for people with disabilities								
	other, please add and describe								
III	**River Crossing onsite (bridges, ferries)**								
	a) crossing by motor vehicles								
	b) crossing by soft modes such as bike, foot, roller blades etc.								
	c) comfortably crossing for people with disabilities								

	parameter (of state) / state classification	descriptions, explanations for state classification delivered annexes	Parameter irrelevant	state before revitalization* (reference date: ………..)			state after revitalization* (reference date: ………..)		
				+	+/-	-	+	+/-	-
	other, please add and describe								
BB	**Social and Cultural Infrastructure**								
I	**Facilities and Infrastructure**								
	a) network of hygiene and health service (restrooms, drinking fountains, trash cans, snackbars, first aid stations, emergency phones, bad weather shelter, water quality information boards etc.)								
	b) network of social service (information centre and information boards etc.)								
	c) network of various meeting and resting places (squares, playgrounds, chairs, banks etc.)								
	d) network of facilities for use of water body (anchorage places, floating piers, docks, bathing facilities etc.)								
	e) accessibility of sites of cultural attractions (e.g. cultural heritage sites as technical/architectonical/industrial monuments, exhibitions, theatre, special restaurants)								
	f) accessibility of nature conservation areas, natural monuments (nature conservation status, biological diversity, rare species etc.)								
	other, please add and describe								
II	**Leisure Time Use**								
	a) area used for historical and cultural education (museum, guided tours, information boards on historical use of river etc.)								
	b) area used for environmental education (e.g. guided tours, environmental centres)								
	c) area used for continuous or seasonal commercial activities (e.g. shopping, boating or ship tours, ballooning, boat rentals, yacht piers)								
	e) area used for special events (e.g. festivals, fairs, concerts, etc.)								
	other, please add and describe								
III	**Active Recreational Use**								
	b) area used for sports on water (canoeing, boating, water sky etc.)								

	state classification / parameter (of state)	descriptions, explanations for state classification delivered annexes	Parameter irrelevant	state before revitalization* (reference date: ………...)			state after revitalization* (reference date: ………...)		
				+	+/-	-	+	+/-	-
	b) area used for sports in water (diving, swimming, etc.)								
	c) area used for other sports along river (fitness trail, bike and skating etc.)								
	d) offer for playful recreation (variety of playgrounds for children etc.)								
	other, please add and describe								
IV	**Passive Recreational Use**								
	a) area used for fishing								
	b) area used for nature observation								
	c) area used for picnicking								
	d) area used for walking and relaxation (sitting, walking, reading, watching, etc.)								
	e) area used for observation from moving vehicles (by train, by tram, by car, etc.)								
	other, please add and describe								
BC	**Social / Aesthetic Perception and Experience of Riverscape**	not all parameters under this section BC can be evaluated, then if relevant for the project please only describe the parameter							
I	**Visual/Spatial along Riverside**	describe and please note in case experiences are seasonal							
	a) presence of focal points (points of visual interests expressing character and identity)								
	b) presence of viewing points (from which focal points can be observed through views, prospects or vistas)								
	c) distinctive open spaces (formed by structures or vegetation)								
	d) offer of transitional spaces (spaces linking open spaces)								
	e) site allows clear orientation (hierarchy of spaces, ways, memorable places etc.)								
	f) visual aversion experiences (interfering, view obstruction, negative views)								
	other, please add and describe								
II	**Smell and Sound along Riverside**	describe and please note in case experiences are seasonal							
	a) positively felt natural odours prevail in the area (e.g.. vegetation, water, biotopes, animals)								

	state classification / parameter (of state)	descriptions, explanations for state classification delivered annexes	Parameter irrelevant	state before revitalization* (reference date: ………...)			state after revitalization* (reference date: ………...)		
				+	**+/-**	**-**	**+**	**+/-**	**-**
	b) negatively felt natural odours prevailed in the area (e.g.. vegetation, water, biotopes)								
	c) negatively felt technical odours prevailed in the area (e.g.. exhaust gases, industrial smells)								
	d) positively felt natural sounds prevailed in the area (e.g.. vegetation, water, animals)								
	e) negatively felt technical/human sounds prevail in the area (e.g.. exhaust gases, industrial smells)								
	other, please add and describe								
III	**Emotional**								
	a) site stimulates identity/character								
	b) site displays novelty, uniqueness, distinctiveness of riverscape (international/national/regional unique character of riverside or offer of elements)								
	c) site creates feelings of mystery/fascination (stimulating exploration of/ interest for riverscape)								
	other, please add and describe								
IV	**Overall Acceptance and Perception of Riverside**								
	a) frequency by local population visitors per day								
	b) frequency by tourists visitors per day								
	c) frequency by school classes								
	other, please add and describe								
BD	**Economic Well-being**								
I	employment rate (percent) in the adjacent area does not differentiate from (+/-), is higher (+) or lower (-) than the average in the rest of the urban area (if shift is not reflected by this classification, please specify)								
II	housing costs (money/area) in the adjacent area does not differentiate from (+/-), is higher (+) or lower (-) than the average in the rest of the urban area (if shift is not reflected by this classification, please specify)								

	parameter (of state) / state classification	descriptions, explanations for state classification delivered annexes	Parameter irrelevant	state before revitalization* (reference date: ………..)			state after revitalization* (reference date: ………..)		
				+	**+/-**	**-**	**+**	**+/-**	**-**
III	development of housing units and offices in the adjacent area does not differentiate from (+/-), is higher (+) or lower (-) than the average in the rest of the urban area (if shift is not reflected by this classification, please specify)								
IV	investment (money/area) to in the adjacent area does not differentiate from (+/-), is higher (+) or lower (-) than the average in the rest of the urban area (if shift is not reflected by this classification, please specify)								
V	migration balance between the area adjacent to the rehabilitation site and the rest of the urban area is stable (+/-), positive (+) or negative (-) (if shift is not reflected by this classification, please specify)								
VI	property value (money/area) in the adjacent area does not differentiate from (+/-), is higher (+) or lower (-) than the average in the rest of the urban area (if shift is not reflected by this classification, please specify)								
VII	number of visitors (?) in the adjacent area does not differentiate from (+/-), is higher (+) or lower (-) than the average in the rest of the urban area (if shift is not reflected by this classification, please specify)								
	other, please add and describe								
BE	**Public Health and Safety**								
II	crime rate (percent in area) in the adjacent area does not differentiate from (+/-), is higher (+) or lower (-) than the average in the rest of the surrounding urban area (if shift is not reflected by this classification, please specify)								
II	accident rate (percent in area) in the adjacent area does not differentiate from (+/-), is higher (+) or lower (-) than the average in the rest of the surrounding urban area (if shift is not reflected by this classification, please specify)								
III	Flood risk in the rehabilitation site area does not differentiate from (+/-), is higher (+) or lower (-) than the rest of the urban floodway of the river (if shift is not reflected by this classification, please specify)								
IV	Flood risk in the areas connected with the state of the rehabilitation site is medium (+/-), high (+) or low (-)								

Measures - Urban River Basin Enhancement Methods (URBEM)
Case Studies of Existing Successful River Enhancement Projects
(C) Physical Measures (rehabilitation targets and techniques)

Name of river : | **concerned river section** (km 'x' to 'y'):

Name of site and project:

Time of revitalization:

Responsible (project) agencies: (Address, Phone, Mail, contact person)

Water body category (according to WFD 'A' for 'river' / B for 'artificial and heavily modified surface water body') :

Person filling out form: (Name, Phone, Agency)

evaluation scale / parameter		description of measure (material and techniques) applied and effect, delivered annexes	Parameter irrelevant	affected size *			project costs *		
				length (m)	**m^2**	**m^3**	**person months**	**material costs**	**total costs**
				* it will not be possible to make all these specifications for all parameters on listed on the left - please fill in the relevant and comment to what they refer					
CA Site Ecology - Technical and Soil-bioengineering Measures addressing ...									
I	**WATER QUALITY**								
1	**Measures to reduce Point Sources of Pollution**								
	a) construction of mechanical treatment plants								
	b) construction of biological treatment plants								
	c) construction of biological treatment plants with enhanced secondary treatment (chemical, ultraviolet light etc.)								
	d) construction of chemical treatment plants (for industry)								
	e) reduction of wastewater through on-site stormwater management								
	f) stormwater storage and treatment								
	other, please add and describe								

parameter / evaluation scale		description of measure (material and techniques) applied and effect, delivered annexes	Parameter irrelevant	affected size *			project costs *		
				length (m)	m^2	m^3	person months	material costs	total costs
2	**Measures to reduce Non-Point Sources of Pollution**								
	a) sediment control (erosion prevention)								
	b) control of chemical pollutants								
	other, please add and describe								
II	**HYDROLOGY/HYDRODYNAMICS**								
1	**Hydrology**								
	a) managing water withdrawal								
	b) adapting the discharge regime to a less disturbed situation								
	c) enhancement of base flow through stormwater infiltration								
	other, please add and describe								
2	**Sediment Balance**								
	a) measures to establish a less disturbed sediment balance								
	other, please add and describe								
III	**CONNECTIVITY**								
1	**Longitudinal Connectivity**								
	a) removal of structural flow and migration barriers (dams, weirs, steps)								
	b) bypassing of structural flow and migration barriers (dams, weirs, steps)								
	c) elimination of ecological barriers (retaining sections, sections with occurring water shortage)								
	d) bypassing ecologically poor river sections								
	e) construction/modifications of damming and/or retaining structures								
	f) restoration of pool/riffle composition								

	parameter / evaluation scale	description of measure (material and techniques) applied and effect, delivered annexes	Parameter irrelevant	affected size * length (m)	affected size * m^2	affected size * m^3	project costs * person months	project costs * material costs	project costs * total costs
	g) restoration of the river gradient								
	h) restoration of stream alignment (according channel type)								
	i) day lighting of streams								
	other, please add and describe								
2	**Lateral Connectivity**								
	a) removing 'hard' (lateral) stream bank stabilisation								
	b) stream bank stabilisation measures (please describe)								
	c) relocation of high water dikes								
	d) re-establishment of floodplain retention areas								
	e) re-establishment of cross sectional depth variation								
	f) widening cross section of channel and floodplain								
	other, please add and describe								
3	**Vertical Connectivity**								
	a) removal of hard bed lining								
	b) infill or/and cleaning of river bed sediments								
	c) enhancement of base flow through re-establishing the connection to ground water body								
	other, please add and describe								
IV	**Biological measures**								
1	**Restoration of Aquatic Vegetation** (species, distribution)								
	please fill in								

parameter	evaluation scale	description of measure (material and techniques) applied and effect, delivered annexes	Parameter irrelevant	**affected size ***			**project costs ***		
				length (m)	**m^2**	**m^3**	**person months**	**material costs**	**total costs**
2	**Restoration of Riparian Vegetation** (species, distribution)								
	please fill in								
3	**Restoration of Aquatic Populations** (habitat, connectivity) **and Fisheries**								
	please fill in								
CB Physical Measures addressing Social and Economic Well-being									
I	**Health and Safety Aspects**								
1	**Flood Damage Prevention**								
	a) constructional flood proofing of structures								
	b) mobile flood protection								
	c) flood warning system								
	other, please add and describe								
2	**Accident Prevention**								
	a) constructional measures to prevent accidents along riverside (e.g. railings, warning signs, information plates)								
	other, please add and describe								
3	**Health and Hygiene Service**								
	a) establishment of hygiene facilities as restrooms, water fountains etc.								
	b) establishment of health service as first aid stations, emergency phones etc.								
	other, please add and describe								

parameter \ evaluation scale		description of measure (material and techniques) applied and effect, delivered annexes	Parameter irrelevant	affected size *			project costs *		
				length (m)	m^2	m^3	person months	material costs	total costs
II	**Accessibility and River Crossing**	size and cost statements non obligatory							
1	**Improving River Crossing**								
	a) construction of bridges/tunnels								
	b) establishment of ferries								
	other, please add and describe								
2	**Access towards and Mobility along River**								
	a) improving and/or maintaining road network for motor vehicles								
	b) improving public transportation availability								
	c) improving access for soft modes								
	other, please add and describe								
III	**Development of Social and Cultural Infrastructure**								
	a) equipping riverside with resting facilities								
	b) equipping riverside with places for fishing								
	c) equipping riverside with facilities for nature observation and educational opportunities (information tables, museum etc.)								
	d) development of water sport facilities								
	other, please add and describe								

parameter / evaluation scale		description of measure (material and techniques) applied and effect, delivered annexes	Parameter irrelevant	affected size *			project costs *		
				length (m)	m^2	m^3	person months	material costs	total costs
IV	**Measures addressing Social Perception and Aesthetical Experience of Riverside**	please describe							
1	**Revitalizing Visual Connections** (e.g. offering viewpoints, clearcutting vegetation)								
2	**Enhance other Visual Experience on Riverside (e.g. plantings, artwork)**								
3	**Improving of Orientation through Establishing of Guidance System** (e.g. orientation signs, application of particular design principles, hierarchy of pathways)								
4	**Improving of Spatial Experience** (e.g. establishing built or vegetative borderlines)								
5	**Remedy Aversion Experiences on Riverside (e.g. protection from noise and pollution imissions, cleaning of riverbanks)**								
6	**Strengthen Identity of Riverside**								
	a) highlighting cultural heritage								
	b) improving narrative knowledge of site								
	other, please add and describe								

Urban River Basin Enhancement Methods (URBEM)
Case Studies of Existing Successful River Enhancement Projects
(D) Planning and Implementation Approach

Name of river : **concerned river section** (km 'x' to 'y'):

Name of site and project:

Time of revitalization:

Responsible (project) agencies: (Address, Phone, Mail, contact person)

Water body category (according to WFD 'A' for 'river' / B for 'artificial and heavily modified surface water body'):

Person filling out form: (Name, Phone, Agency)

		Description / Comments
DA Initiation		
	a) responding to legal demands by regulatory agency prescriptions	
	b) council initiative	
	c) civic stakeholder initiative	
	d) interest group initiative	
	e) disposition of resources	
	other, please add and describe	
DB Legal Background		
	a) legislation regulating restoration process	
	b) legislation at different levels (e.g. national, state, local) enabling/ backing rehabilitation	
DC Finance Instruments		
I	**Public Budget**	
	a) budget resources from different administrative levels (e.g. European, national/federal, regional, local)	
	b) rehabilitation programs	
	other, please add and describe	
II	**Private Sponsorship**	
	a) local/regional/other sponsors	

		Description / Comments
	b) private funds and/or programs	
	c) services in return	
	other, please add and describe	
III	**Financial or Tax Incentives**	
	other, please add and describe	
DD Selection of Rehabilitation Site		
	a) selection method	
	b) selection procedure	
DE Official Procedure of Rehabilitation		
I	**Organisation**	
	a) special project group or board formed	
	b) private developer involvement	
	c) staff assigned with the project (persons, duration, costs)	
	d) site administration staff (before, during, and after implementation)	
	other, please add and describe	
II	**Time Line** (dates, duration, costs)	
	a) initiation idea	
	b) funding process	
	c) planning process	
	d) implementation	
	e) post-implementation appraisal	
	other, please add and describe	
DF Performance Control		
I	**Investigation before Implementation**	
	a) investigation criteria (any)	
	b) results	
	c) costs	
	d) time line	
II	**Success / Process Monitoring during Implementation**	
	a) monitoring criteria (any)	
	b) results	

		Description / Comments
	c) costs	
	d) time line	
II	**Success Monitoring after Implementation**	
	a) monitoring criteria (any)	
	b) results	
	c) costs	
	d) time line	
DG Stakeholder involvement (please describe methods/ideas and influence of involvement on enhancement process)		
I	**Citizens**	
1	**Formal Involvement**	
	a) legal requirements for citizen public participation (for planning and implementation process)	
	b) actually implemented participation process (concepts, fulfilling or exceeding legal requirement)	
2	**Informal Involvement**	
	a) in course of different project phases	
	b) collection of ideas	
	c) determination of potential sites	
II	**Other Stakeholder Groups**	
	a) political groups	
	b) non-government organisations	
	c) commercial associations (tourism, etc.) or single businesses	
	d) other social groups	
III	**Evaluation of stakeholder involvement**	
DH Stewardship and Advocacy		
	a) partnerships and coalitions for river stewardship	
	b) voluntary clean-up events	
	c) river advocacy through continuous activities (e.g. website, newsletter)	

		Description / Comments
	d) river advocacy through single events (Festivals)	
	other, please add and describe	
DI Layout/Design/Structure of Public Information (please describe any specific concept/layout/content idea and if possible, please submit examples)		
	a) paper related (brochures, billboards, newspaper/journals)	
	b) internet/local TV-Station/Radio	
	c) presentations, lectures etc.	
	other, please describe	
DJ Administration and Management before and after Implementation		
I	**Staff needed for Site Administration**	
	a) municipal administration (site monitoring, marketing etc.)	
	b) security	
II	**Site Maintenance Staff and Expenditures**	
	a) staff engaged with maintenance of site (incl. river section)	
	b) staff engaged with maintenance of river section	
	c) expenditures for site maintenance (incl. river section)	
III	**Management Mode**	
	a) please describe management mode of the rehabilitated water body - if changes have occurred please name (e.g. allowing for: bank and river bed erosion, natural river bed allocation, woody debris in the river channel etc.)	
	b) please describe management mode of the rehabilitation site - if changes have occurred please name	

Urban River Basin Enhancement Methods (URBEM)
Case Studies of Existing Successful River Enhancement Projects
Strengths and Weaknesses of the Project

Name of river : **concerned river section** (km 'x' to 'y'):

Name of site and project:

Time of rehabilitation:

Responsible (project) agencies: (Address, Phone, Mail, contact person)

Water body category (according to WFD 'A' for 'river' / B for 'artificial and heavily modified surface water body') :

Person filling out form: (Name, Phone, Agency)

This page is meant to deliver information individual to any site and its special context that can not be covered by the general form. It will provide the necessary individual context for the formal standardised data. Please mention any facts, circumstances, outcomes etc. that you think are important for the understanding of the project. To learn about the project strengths have the same importance as its possible weaknesses.

I Strengths of the Project

II Weaknesses of the Project

Urban River Basin Enhancement Methods (URBEM)
Case Studies of Existing Successful River Enhancement Projects
Project Outline - Background Information

I Name of River and Program/Project	
a) river name	
b) project name	
c) case study (site) name	
d) contact Person(s)	
Institution/Organisation	
Name	
Mail address	
Phone	
Email	
e) Person filling out form: (Name, Phone, Agency)	
II General Background Information on River and River Basin	
a) Basin extent (km2)	
b) river length	
c) basin characterisation (hydrologic network, landscapes, land uses)	
d) average discharge onsite (m3/s)	
e) average discharge at river mouth (m3/s)	
f) major obstructions onsite influencing wild life	
g) sediments (grain sizes in the substrate matrix, D50 in mm) and sediment balance (discharge in t/year; natural / impacts by upstream structures or land uses)	
h) particular flood and drought events	
i) impact of upstream structures (dams, large sealed areas etc.)	
j) ongoing programs and projects within the basin	
III Background Information in Case Study Area	
a) location of river section in river system	
length of section (m):	
from river km (from source):	
to river km (from source):	
b) size of rehabilitated area (m2)	
c) channel type (Rossgen, see table below)	
d) river zone (Huet, see table below)	
e) major changes occurring within area (hydrology, ecology, water quality, urban area etc.)	
f) historical development of area	
g) environmental development of area	
h) general description of conditions (positives and negatives)	
IV Short Project Characteristics	
a) reason given for project (Why was it necessary to conduct the project?)	
b) Project's main emphasis	
c) goals, visions, objectives of the project (please name and describe in as much detail as possible)	
Project Costs (planned / actually paid)	
a) planning costs	
b) implementation costs (physical measures)	
c) land purchase costs	
d) monitoring costs	

Urban River Basin Enhancement Methods (URBEM)

Case Studies of Existing Successful River Enhancement Projects

Read me - Purpose, Method Explanation, Guide for Data Delivery, Contact Information

0 WHY do we require data from special case studies?

The overall aim of the URBEM project is to provide a comprehensive framework to facilitate urban watercourse rehabilitation that takes into account the regional variations in modification and use of watercourses across Europe. The most innovative rehabilitation schemes from different European countries as well as abroad will serve as reference projects.

The objectives of URBEM are:

- To develop new tools to assess the potential for enhancement and rehabilitation of urban watercourses,
- To develop innovative urban watercourse rehabilitation techniques for use in future schemes,
- To find and to validate indicators of success usable for comprehensive success evaluation of future rehabilitation schemes,
- To develop decision making support procedures, including social, economic, environmental and safety aspects, to help planners and city authorities effectively prioritise and plan urban river rehabilitation projects that help to achieve "maximum ecological potential".

The information gathered on the rehabilitation schemes chosen will be processed by the other research partners within the URBEM project to cope with the goals named above.

The information on reference **case studies and scientific results** will be available for city and community authorities as well as for interested individuals as they are looking for planning and implementation examples in the field of urban stream enhancement. Case studies will be available on the internet and as a brochure. **Further information** can be obtained from the project web page: **www.urbem.net** or by contacting one of the contact persons named below.

1 Method Why do we gather the information the way we do?

This data inquiry form allows the enquiry of standardised as well as non standardised data referring to rehabilitation projects. **The form is meant as a guide for data inquiry. We will assist you in filling out the form and collating the necessary data.**

First the **'Project outline'** gives an overview about the case study area, the study itself as well as goals and objectives of the rehabilitation scheme. Secondly the page **'Strengths and Weaknesses'** allows to elaborate on issues that can not be addressed by the other tables of the data inquiry form. Following sheets will ensure a common data base for all case studies of the whole URBEM project:

(A) Ecological and chemical state
information on the state of waters using standardised parameters set by the European water framework directive. This data will guarantee the most comprehensive characterisation of waters according Europe wide standards.

(B) Social and economic well-being
complementary to (A) this page gives information on socio-economic state of rehabilitation sites. As there is no set methodology for collecting this data the page reflects a variety of issues that we have kept as impartial as possible.

(C) Physical measures (rehabilitation targets and techniques)
data collection of physical measures which address ecological and socio-economic aspects, including descriptions on materials and techniques used, which will be processed to a catalogue of "best practice techniques".

(D) Planning and implementation approach
data collection on possible approaches to river rehabilitation, from initiation via planning to implementation and monitoring of success including participation processes.

Since we deal with very different legislative, administrative, ecological and practical situations in Europe, some aspects of your case study might not be covered by this form. Then please fill in the information in the most appropriate place or contact one of us. Other aspects again may not be relevant for every case study.

2 Contact information

for further information regarding the case study please contact:

Institute for Ecological and Regional Development (IOER):	Dresden University for Technology (TUD):
Alfred Olfert	Ines Gersdorf, Thomas Schwager
Phone: +49 (0)351 4679 - 233	Phone: +49 (0)351 463 - 33453 / 32346
Fax: +49 (0)351 4679 - 212	Fax: +49 (0)351 463 - 37081
Email: A.Olfert@ioer.de	Email: urbem@mailbox.tu-dresden.de
Weberplatz 1	Institute of Landscape Architecture
D-01217 Dresden	Mommsenstraße 13
	D-01069 Dresden, Germany

3 HOW to transmit data

Flexible Information transfer will be crucial for the collecting of information. Since we are on a very tight schedule, digital data, as far as possible, is preferred. Feel free to contact us for more information and help on the file transfer.

Institute for Ecological and Regional Development (IOER):	Dresden University for Technology (TUD):
Digital data: Files up to 25 MB via email Email: A.Olfert@ioer.de	**Digital data via ssh:** (files up to 10 MB via email) Host Name: rcs7.urz.tu-dresden.de User Name: Urbem Port Number: 22 Password: has been send to you via e-mail or ask for it **Installing ssh-Client:** in case you not using ssh-clients for file transfer yet, you can go to www.tu-dresden.de/urbem and follow “Instructions on how to use the SSH-Client”. Installation of software is free and takes about 5 minutes.
Mail: Institute for Ecological and Regional Development (IOER) Weberplatz 1 D-01217 Dresden	**Mail:** Dresden University of Technology, Institute of Landscape Architecture Mommsenstraße 13 D-01069 Dresden

4 WHEN Timeline

End of June:	finishing data collection on case studies
End of September:	completion of report

Annex 2 Description of techniques

2 Rehabilitation techniques

Techniques implemented in the analysed case studies will be presented here. It has been found that techniques mentioned by case study partners did not follow standardized names, that many commonly described techniques were adapted to site specific conditions and that many cases applied a conglomerate of more than one technique. Consequently, to provide a basis for further understanding techniques found in case studies are supplemented by a short description, whereas a revision of descriptions and detailing as well as completion of techniques will be part of further investigations in the URBEM Project. Where appropriate, techniques are visualised and supported by site-specific examples from the case studies. In addition to the techniques strategies for implementation of urban river rehabilitation are included and marked with (S) for strategy. The classification of measures follows Chapter 5.

2.1 Improving hydrology and hydrodynamics

Wet ponds with extended detention

Wet ponds with extended detention are an effective way to combine water quality improvement, peak flow control, and other multiple uses including water-based recreation. Runoff is released via a spillway that controls rate and time of discharge.

Porous pavement: Modular-paving blocks

Modular pavers can be made of either concrete blocks and brick, or plastic grids. They provide a surface of up to 75% permeable gravel or soil and thus allow water to gradually infiltrate. Below the filter course or bedding layer, a choker course is installed.

Infiltration basins

A water impoundment made by excavation or construction of an embankment to intercept runoff and to maintain or increase natural groundwater recharge by infiltration through the bed and sides of a pond or basin. It is sized to hold and infiltrate the runoff from a design storm (e.g. at two year frequency storm).

La Chaudanne (Lyon) - Infiltration basins

Runoff is discharged into a cascade of 3 storm water detention and infiltration basins (125, 780, 780 cubic meter). The scheme is laid out to detain a flood of a four to five year’s frequency. The outlet from the downstream basin is regulated automatically by a floater-controlled lock bar allowing a limited flow rate of 216 l/s to enter a subsurface filter from where the water is finally released into the stream La Chaudanne. The filter system serves as trap for organic material. The release rate corresponds to the natural regional runoff on a non-urbanisation area of the same size.

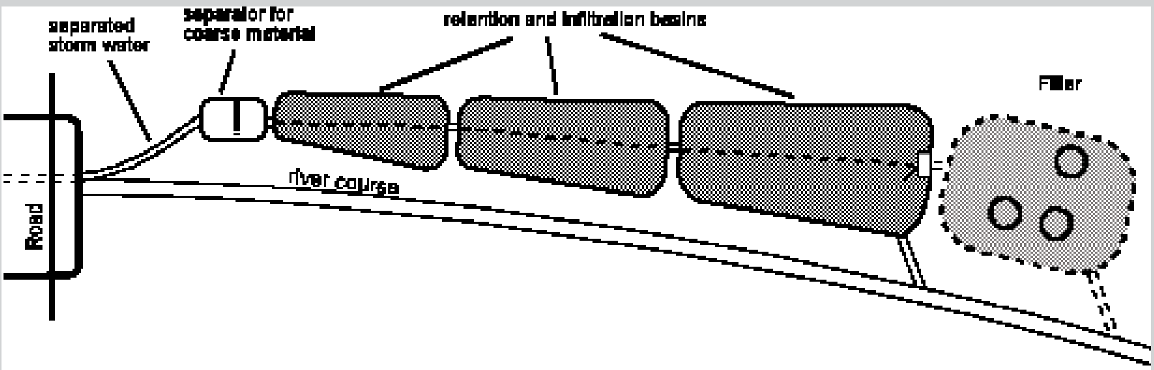


Figure 1: Schemata of infiltration basins at the Chaudanne detention basin

La Chaudanne (Lyon) - (continuing)

Figure 2a,b (top): Second and third (background) detention basins
Figure 3a,b (bottom): An intermediate filter system is installed between the third detention basin and the discharge pipe connecting the system with the stream

Gravel filled trenches / Dutch drains with optional drainage pipe in base

Gravel filled trenches (with an optional distribution pipe in their base) are groundwater infiltration and pollutant removal devices installed close to runoff-generating surfaces. Water is stored within the void volume of the gravel and gradually filters into subsoil. Trenches remove both soluble and particulate pollutants through interaction with soil.

(S) Detaining peak flow

Urbanisation will not only increase the volume of runoff, but will also decrease the time of concentration. As a result streams receiving urban runoff need to accommodate high volume peak flows that are reached in a shorter time than streams in rural areas. This results in flooding and related flood damages. De-centralised storm water detention has been widely accepted as a means of guarding against increased peak rates of discharge and prolonged flooding. Detention facilities temporarily hold water and provide for a delayed discharge.

Anacostia (Washington D.C.), White Clay Creek (Wilmington, DE) - Mitigating site development effects of peak flows

Storm water management ordinances in the Washington, DC and Wilmington, DE areas require that post-development run-off peaks do not exceed pre-development peaks. This is applying a „user pays“ concept to storm water management, requiring that those who cause run-off should be responsible for its control. The type of measures employed are chosen by the consulting engineer who has needs to supply run-off calculations for a 2, 5, 10, 20, 50, and 100 year storm event of 24hour duration. Review and approval agencies specify the type of software used for these calculations, so that they can be double-checked. The size of run-off detention facilities on the Anacostia and Christina River (whereof the White Clay Creek is a tributary) are enormous. In contrast, European retention facilities that rely on infiltration usually use a 5-year frequency storm of fifteen-minute duration only.

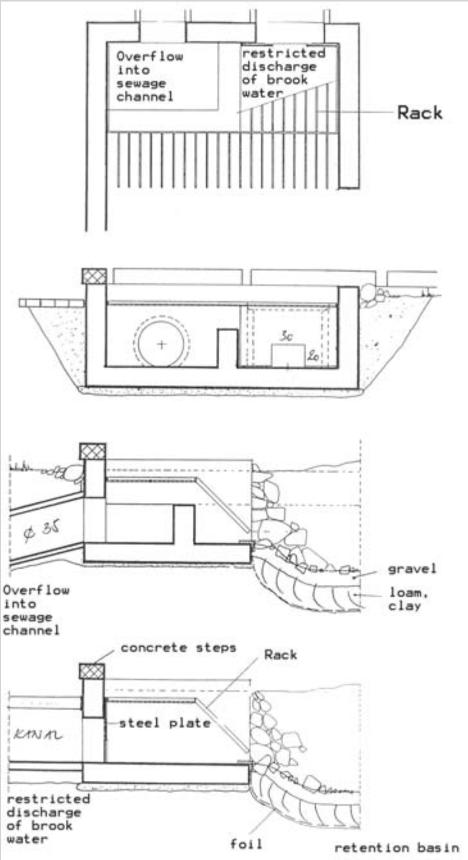
Dry (ponds) detention basins

These basins consist of a dry depression in the ground designed to temporarily detain and slowly release storm water runoff at a predetermined rate. Shallow basins can be maintained with a cover of grass and may permit multiple uses.

Wet detention basins

A permanent pool of water is the distinct characteristic of a wet detention basin. It can provide multi-purpose benefits including recreation. Water quality should be maintained and the pool should be integrated into urban uses through careful design.

Albisreader Dorfbach, Brook Concept Zurich, Zurich - Wet detention basin



The Brook Concept Zurich separates combined sewage pipes carrying spring water and sewage. Spring water is brought back to the surface into newly designed brook beds. Upstream of daylighted brooks detention basin are installed, limiting the discharge of water. In some cases those basins also functioning as sediment and gravel filter. The continuous limited discharge allows daylighting of brooks in spatially restricted areas. The discharge of the detention basin is calculated according to the targeted wide of cross-section. This approach limits ecological enhancement, but provides an option for daylighted brooks under spatial constraints.

Figure 4: Sections of detention basin at the Sägertenbach, Brook Concept Zurich
Figure 5: Detention basin at the Sägertenbach, Brook Concept Zurich

2.2 Improving stream morphology

2.2.1 Measures enhancing in stream morphology

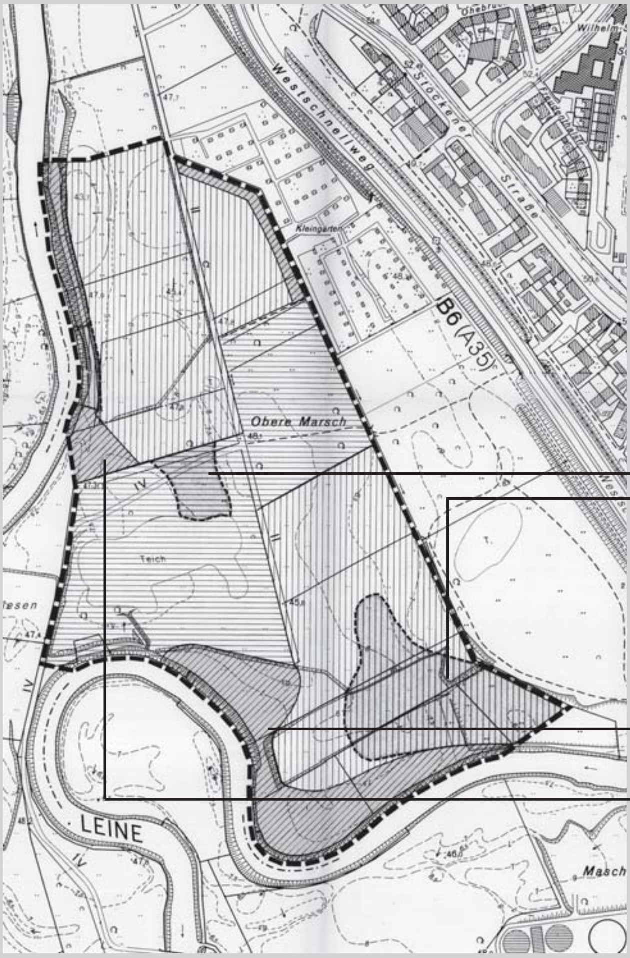
(S) Removal of hard constructions

Hard constructions along urban river channels and beds limit habitat functions, and prevent natural hydromorphologic and hydrologic processes, thus the ecological system is heavily influenced and degraded. Wherever surrounding infrastructure leaves the option to remove hard construction or to replace it with soft revetment techniques, this should be done and natural relocations of the river should be allowed at least to a certain extend. In very restricted sections, compromises such as covering hard constructions with natural material or an installation underground scour/erosion control should be considered.

(S) Process initialisation

Useful wherever basic conditions permit enhanced natural processes. The technique makes advantage of natural dynamics of watercourses by only introducing initial changes and allowing for natural development promoted by the force of the water. The technique requires good understanding of hydromorphological processes of the watercourse and needs a permanent supervision for possibly necessary interventions.

Leine (Hanover) - Process initialisation



At the Leine dykes where opened to allow the flooding of the valley. Parts of the flood plain where lowered to increase the frequency and duration of flooding. Despite the „federal water way“ status of the Leine river quarry stones stabilising the river banks along the insides of bends were partly removed. These measures allowed for more natural processes in the floodway. Ecological enhancement was combined with an improved flood management and public accessibility.

Improving site conditions:

- enhancing inundation dynamics and following inundation height and period, velocity, erosion and sedimentation
- Lowering the embankment
- Deepening and widening of existing drains and depressions

Initialising site specific vegetation:

- Planting of a coherent vegetation cover along the main channel of the river
- Initial planting of an alluvial forest

Figure 6: Map of ecological revitalisation at the Leine

(S) Infill of bed load

Stone and gravel are placed into the wetted perimeter of streams that are deficient of this bed load. The goal is to protect the channel bed from further degradation, to increase habitats for aquatic life forms and to provide spawning areas for some fish species. This can be done in form of stone and gravel banks. In cases of unnatural sediment deposit a cleaning or exchange of sediments may be advisable. Cleaning can be supplemented by the addition of external sediments of appropriate grain size. But in any case sediment input should go along with measures to stabilise sediment balance considering sediment entry and possible sediment loss.

Náhon (Chrudim) - Placement of gravel banks on base of geomorphologic modelling

The old and impounded mill race in the town centre of Chrudim was replaced by a quasi-natural stream sediment deposits in were removed from the old channel. Gravel material was introduced into the newly shaped stream. Stream alignment and grain size of bed sediments were modelled for a foreseen naturalistic discharge regime and taking into account the restored gradient of the stream. As basis for stream design geomorphologic modelling was employed and today neither siltation nor erosion could be observed in the streambed.

Figure 7: The old mill race in Chrudim
Figure 8: 2003 - The new stream channel instead of old mill race based on geomorphologic modelling

Isar (Munich) - Input of cobble and gravel

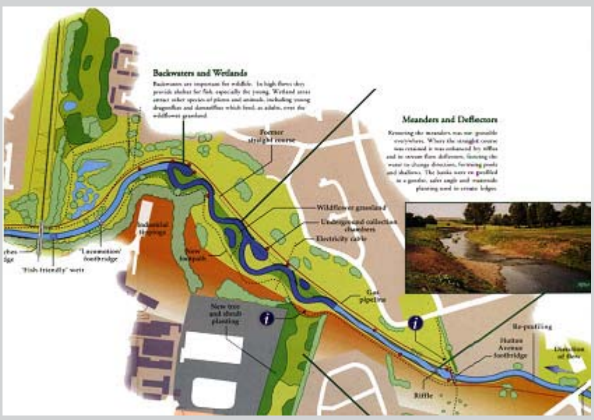
The Isar is a river with a high flow velocity and therefore, naturally carries a high amount of bed load. Before the rehabilitation the riverbed was fixed with low drops to protect the riverbed from erosion and to minimize gravel transport. The goal to establish more natural hydromorphologic processes resulted in the removal of hard confinement, the replacement of the low drops by sills and in the input of gravel and boulders along the banks and as islands. With time those gravel banks will be relocated trough natural processes within the confinements of levies. During summer those gravel banks are used by thousands of people for recreation.

Figure 9: New gravel banks used for recreation
Figure 10: Map of new gravel banks

Brush mattresses

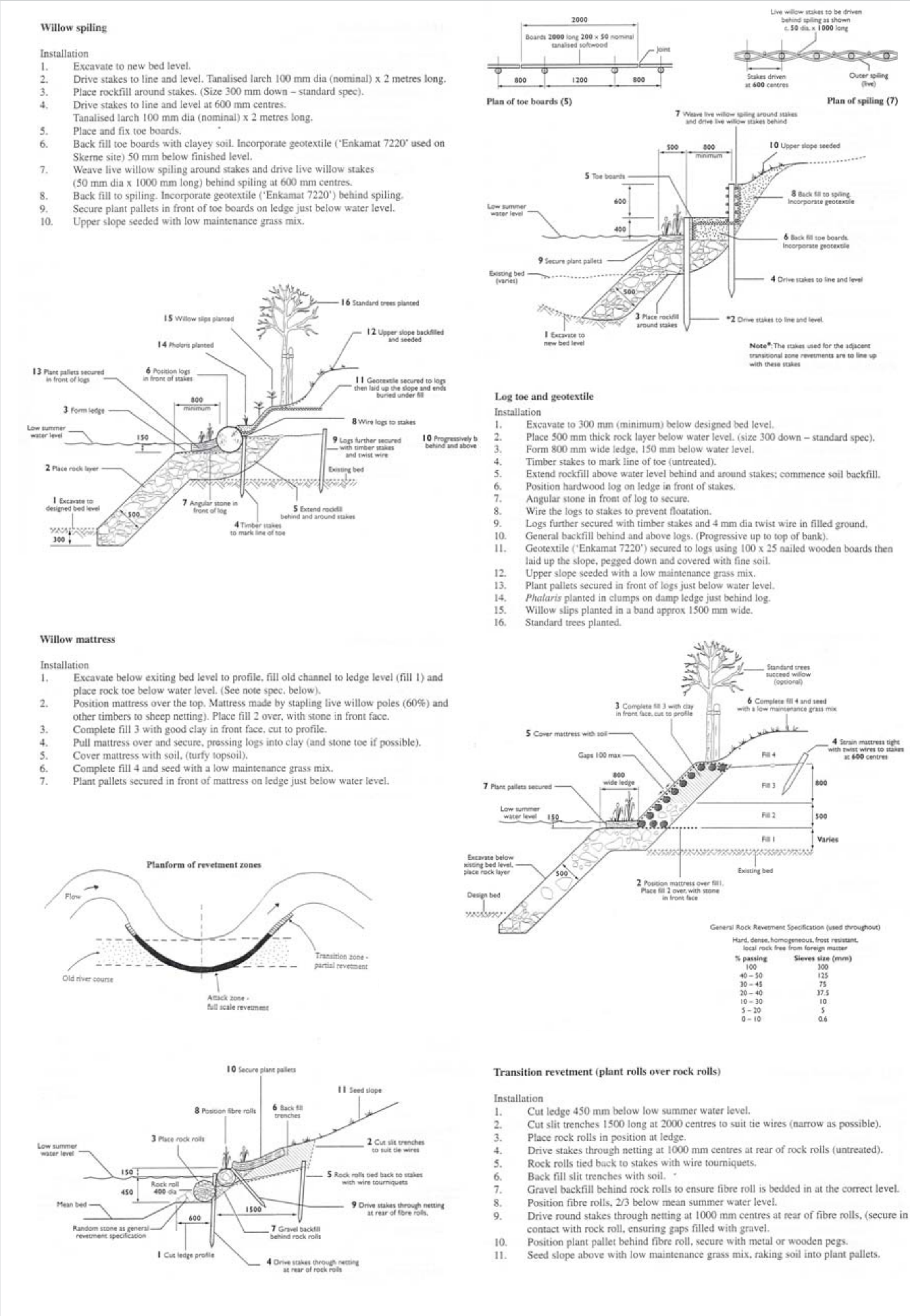
Thick layers of live branch cuttings of more than 1,50 m length are placed to cover and protect the ground. Rows of dead stout stakes are driven in 1 m spacing and connected with wire. Branches are covered with a thin layer of soil to enhance ground contact. The toe of the installation may be protected through rocks and a live fascine.

Skerne River (Darlington) - restoration of previous stream alignment through Willow Mattress, Revetment Techniques



The formerly straitened river channel of the Skerne River was restored, using historic maps and hydrologic modelling. Meander were reintroduced in sections were enough space was available. For the protection of the new and more natural alignment in confined areas (confinements by gas and power lines) soft revetment techniques were applied. In attack zones (see sketch on next page) this included willow matress, willow spilling, log toe and geotextile and in transition zones plant rolls over rock rolls were used.

Skerne River (Darlington) - continuing



Willow spiling

Installation

1. Excavate to new bed level.
2. Drive stakes to line and level. Tanalised larch 100 mm dia (nominal) x 2 metres long.
3. Place rockfill around stakes. (Size 300 mm down – standard spec).
4. Drive stakes to line and level at 600 mm centres. Tanalised larch 100 mm dia (nominal) x 2 metres long.
5. Place and fix toe boards.
6. Back fill toe boards with clayey soil. Incorporate geotextile ('Enkamat 7220' used on Skerne site) 50 mm below finished level.
7. Weave live willow spiling around stakes and drive live willow stakes (50 mm dia x 1000 mm long) behind spiling at 600 mm centres.
8. Back fill to spiling. Incorporate geotextile ('Enkamat 7220') behind spiling.
9. Secure plant pallets in front of toe boards on ledge just below water level.
10. Upper slope seeded with low maintenance grass mix.

Note*: The stakes used for the adjacent transitional zone revetments are to line up with these stakes

Log toe and geotextile

Installation

1. Excavate to 300 mm (minimum) below designed bed level.
2. Place 500 mm thick rock layer below water level. (size 300 down – standard spec).
3. Form 800 mm wide ledge, 150 mm below water level.
4. Timber stakes to mark line of toe (untreated).
5. Extend rockfill above water level behind and around stakes; commence soil backfill.
6. Position hardwood log on ledge in front of stakes.
7. Angular stone in front of log to secure.
8. Wire the logs to stakes to prevent floatation.
9. Logs further secured with timber stakes and 4 mm dia twist wire in filled ground.
10. General backfill behind and above logs. (Progressive up to top of bank).
11. Geotextile ('Enkamat 7220') secured to logs using 100 x 25 nailed wooden boards then laid up the slope, pegged down and covered with fine soil.
12. Upper slope seeded with a low maintenance grass mix.
13. Plant pallets secured in front of logs just below water level.
14. *Phalaris* planted in clumps on damp ledge just behind log.
15. Willow slips planted in a band approx 1500 mm wide.
16. Standard trees planted.

Willow mattress

Installation

1. Excavate below exiting bed level to profile, fill old channel to ledge level (fill 1) and place rock toe below water level. (See note spec. below).
2. Position mattress over the top. Mattress made by stapling live willow poles (60%) and other timbers to sheep netting). Place fill 2 over, with stone in front face.
3. Complete fill 3 with good clay in front face, cut to profile.
4. Pull mattress over and secure, pressing logs into clay (and stone toe if possible).
5. Cover mattress with soil, (turfy topsoil).
6. Complete fill 4 and seed with a low maintenance grass mix.
7. Plant pallets secured in front of mattress on ledge just below water level.

Planform of revetment zones

General Rock Revetment Specification (used throughout)

Hard, dense, homogeneous, frost resistant, local rock free from foreign matter

% passing	Sieves size (mm)
100	300
40 – 50	125
30 – 45	75
20 – 40	37.5
10 – 30	10
5 – 20	5
0 – 10	0.6

Transition revetment (plant rolls over rock rolls)

Installation

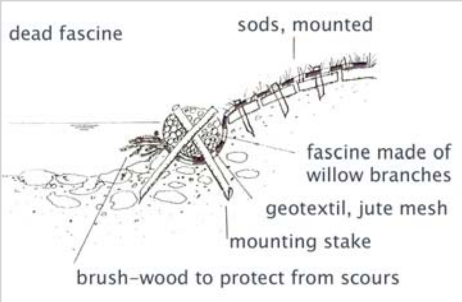
1. Cut ledge 450 mm below low summer water level.
2. Cut slit trenches 1500 long at 2000 centres to suit tie wires (narrow as possible).
3. Place rock rolls in position at ledge.
4. Drive stakes through netting at 1000 mm centres at rear of rock rolls (untreated).
5. Rock rolls tied back to stakes with wire tourniquets.
6. Back fill slit trenches with soil.
7. Gravel backfill behind rock rolls to ensure fibre roll is bedded in at the correct level.
8. Position fibre rolls, 2/3 below mean summer water level.
9. Drive round stakes through netting at 1000 mm centres at rear of fibre rolls, (secure in contact with rock roll, ensuring gaps filled with gravel.
10. Position plant pallet behind fibre roll, secure with metal or wooden pegs.
11. Seed slope above with low maintenance grass mix, raking soil into plant pallets.

Figure 11 (left page): Originally straitened Skerne River restored following historic maps
Figure 12: Revetment Techniques used at the Skerne River

Live fascines/ fascine bundles/ sinking fascines

Bound, elongated bundles of live cut branches are placed in shallow trenches, partly covered with soil, and staked in place to arrest erosion and shallow mass wasting.

Kaitzbach (Dresden) - dead fascines to protect from scouring



The cross section of the Kaitzbach was widened. To protect the newly modelled banks from erosion sods and jute mesh covered them. At middle water level the banks were protected by a dead fascine. The fascine protects from scouring, as long as the grass on the banks is not established yet. It was fixed by willow stakes and a layer of brushwood underneath the fascine provides for additional scouring protection.

Figure 13: Sketch of a dead fascine, used along the Kaitzbach
Figure 14: Dead fascine at the Kaitzbach, about eigth weeks after construction, 1999

Groynes, log cribbing deflectors, and current deflectors

Made of logs or stone, current deflectors are a widely used structure, jutting into a stream to divert currents away from the bank to minimise erosion or to produce oscillating water current in straitened and over widened river sections. Deflectors may be used to cause the stream to deepen the channel and so establish its course.

Live cribwalls (syn. Krainer wall)/ Live slope grating

Chambers of interlocking logs are filled with alternating layers of soil and live branches creating a nearly vertical wall with a slight incline. Live cribwalls are usually more than two meters high. Construction starts with rock filled chambers below water level, and with logs secured with reinforcing bars. Cribwalls may be covered with vegetation in a single growing season. Similar to a cribwall, a live slope grating is a lattice-like arrangement of vertical and horizontal timbers laid to the surface of a steep slope. Openings in the structure are filled with backfill material and live branch cuttings are placed in a manner similar to brush layering. On the toe of the slope a trench of approximately one meter depth is established to secure the grating against slippage.

Live willow racks

Living willow racks are groin-like structures of stone and cuttings of sturdy live willow branches driven into the ground in an angle of 30-45 degrees. The willow branches are placed in the direction of flow and are secured with large stones. After sprouting willow racks will slow down floodwater flows and lead to the deposition of sediments, stabilising stream bends.

Log root wad and boulder revetment

In deeper streams tree trunks can be buried into the streambank at a 90 degrees angle to the stream flow with their root wads exposed underwater. The logs are weighed down with boulders1.5 times the diameter of the trunk. Exposed roots slow the flow of water, trap sediments, and create in-stream habitat structure for fish spawning and rearing. Log root wads and boulder revetments can be used as a secured foundation for further soil-bioengineering installations.

Reed-roll revetment and biologs

Cylindrical, earth filled coconut fiber rolls, approximately six meter in length and 0,3 meter in diameter. They are staked into place at the foot of the streambank. Rolls have a life expectancy of 6 to 10 years. Vegetation planted behind rolls further secures the streambank. Biologs contain a mix of earth, gravel, reed rhizomes and herbaceous plants that sprout through the netting and secure the bank with their roots.

Alterbachsystem (Salzburg) - vegetated rock gabions

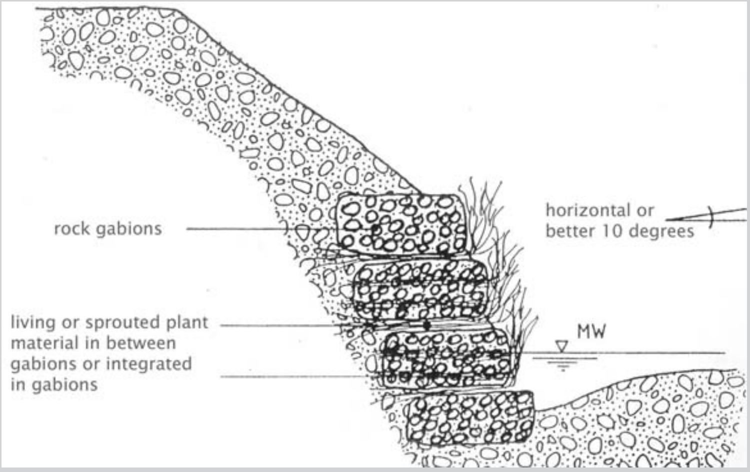


Figure 15: Vegetated rock gabions along the Alterbach

Along the Alterbach vegetated rock gabions have been used to stabilize and protect steep banks. Gabions are made out of a small meshed wire grid filled with coarse gravel. Living sticks or sprouted plants are incorporated. Stabilisation is enhanced through the roots of vegetation and the connection of all elements.

Rock gabions, vegetated rock gabions

Gabions are rectangular wire baskets made of heavily galvanisation or coated wire mesh. They are filled with small to medium sized rock and soil. Gabions are laced together to form terraces or a wall. Placing live branches between each layer of rock filled baskets incorporates vegetation.

La Saone (Lyon) - subsequent vegetation on steep boulder rip rap

Figure 16: Zones of intervention in the Saône re-vegetation

Along the banks of the Saône a stone riprap was re-vegetated by utilisation of an adopted technique being developed especially for the extremely confining situation. No space was available to extend the narrow embankment area due to a parallel road, no changes could be introduced to the hard bank lining due to navigable waterway status of the Saône River. Under these extremely confining circumstances the best possible solution was attempted by a re-vegetation effort covering the steep riprap.

La Saone (Lyon) - continuing

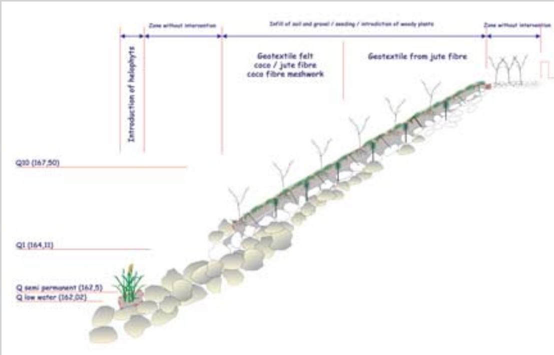


Figure 17: Zones of intervention in the Saône re-vegetation

The narrow embankment was divided into several segments parallel to the river (Figure 17). These responded different exposure to the river during low and high water as well as to different moisture and gradient attributes of the underground. In the upper part two different seeding of herbaceous and planting of woody plants was performed into soil material specially attached with different geo-textiles. The subsequent, most steep part had to be left without intervention due to physical limits of re-vegetation. In the bottom part in transition into the artificial impoundment of the river initial plantations of helophytic plants were realised.

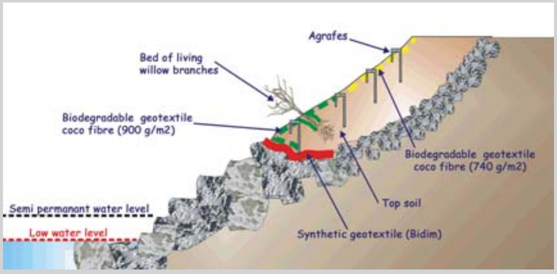
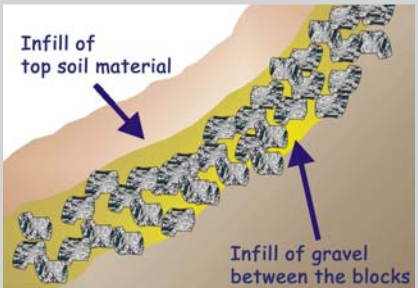


Figure 18: Realisation of the upper part

As basis for plantation in the upper part topsoil material was placed on the thick riprap cover of the embankment. A gradient interruption leading to the most steep portion of the bank was used foundation for the topsoil layer (figure 18). A synthetic geo-textile (Bidim) layer was used to avoid loss of moisture and wash out of fine soil particles into the river. Onto this a first soil layer followed by living willow branches covered again with topsoil was placed to introduce fast natural stabilisation. This most high water exposed section was attached using a combined coco and jute geo-textile (900 g/m^2) and fixed with iron agrafes, which were additionally fixed with concrete between the blocks.The upper part of the section was as well covered with topsoil and attached with a jute geo-textile (749 g/m^2) and also fixed with iron agrafes. Afterwards in small openings woody plants were planted and a mixture of herbaceous plants was seeded.

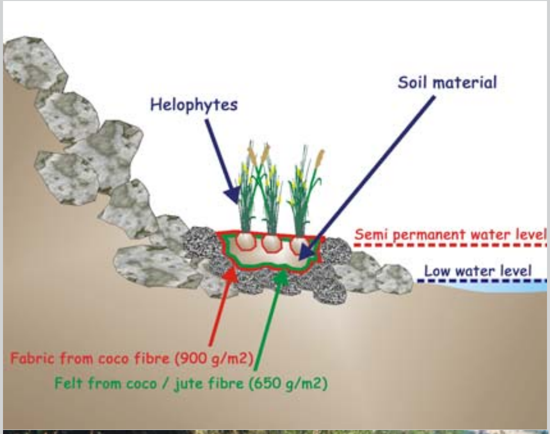


After the experimental application of the technique in the first part of the rehabilitation site a loss of fine material through percolation into the riprap was identified to be a problem and solutions were looked for to mitigate the extreme moisture regime induced by the cavernous riprap. A good effect had the before hand infill of the riprap layers with gravel and soil (Figure 19). This increased the efforts and costs but was effective in decreasing loss of soil material and stabilising the moisture regime and is useful for improving spatial availability for rooting.

In the bottom part of the rehabilitation site initial plantings were introduced in the transition area to the permanent impoundment of the river. Though not necessarily responding to reference condition of a natural river the introduction of aquatic plants is an attempt to improve the current situation where due to the artificialised state of the water body no natural vegetation can establish. However, it is expected that aquatic vegetation will improve habitat availability in the river and will also additional cover the lower uncovered segment of riprap.

Figure 19: Infill of gravel material into the riprap to avoid loss of soil material and to improve moisture capacity of the underground
Figure 20: Geo-textiles covering rip rap

La Saone (Lyon) - continuing



Vegetated niches fixed in the riprap material have been established to introduced helophytes (Figure 21). Between the stone blocks soil filled pockets stabilised with geo-textiles from coco fibre and coco/jute felt were placed. The goal is to establish an initial asset of plants that would naturally spread through sub surface rhizomes.

Figure 21: Introduction of helophytes in the transition area to the permanent impoundment
Figure 22: Placing helophyte niches
Figure 23: River bank of the Saone river after re-vegetation

(S) Pool - Riffle Design

A pool-riffle design of the riverbed is important for habitat functions, especially in river sections with high-flow velocities (Rhithral zone). Diverse flow velocities created trough a pool-riffle-design assist in the accumulation of gravel beds along the river, establishing divers habitats for different species. A pool-riffle structure can be initiated through diverse morphological measures as groynes, ground sills, ramps, low drops and comparable measures. Pool-riffle-design increases DSO level and consequently improves water quality.

Block ramp/ Racks

Differences of level within the streambed can be overcome through steps of large sized coarse rocks, placed loosely into the streambed. They function as an energy dissipater and as a non-erosive surface. These rocks are secured in place by their own weight. Racks are similar to block ramps, though rocks are individually placed and each one is secured in place through wooden or steel pegs. Rocks need to be larger than the bed gravel load transported by the stream. Racks tend to have a highly naturalistic appearance.

Rough bed ground ramps/ rock ground ramps

These ramps are used for stabilising a streambed where differences in level have to be overcome at short distances. The body of the ramp is built of rocks that are narrowly set to create cascades. Poles at the top and bottom of the structure stabilize the ramp that is meant to be flexible enough to permit a slight shifting during flood events.

Sills as transverse structures

Timber logs and/or rocks create a swell that is less than 30 cm high. Like other transverse structures it collects and retain gravel, deepens existing pools, creates new pools above and/or below the structure and promotes deposition of organic debris. Sills also hinder scouring of the channel bed and stabilize it.

2.2.2 Measures enhancing floodplains

(S) Floodplain re-establishment

In urban areas floodplains are often separated from the river and filled. To enhance ecological qualities floodplains should be re-established trough removal of hard bed lining, by lowering floodplain elevations and by re-establishing flood storage capacities.

(S) Maintenance and reforestation of riparian forest buffers

Riparian forests that grow at the edges of water bodies play an important role in cleansing surface water and groundwater. Research has shown that forest soils and the roots of riparian forests retain nitrogen and phosphorus of storm water through assimilation, nitrification and de-nitrification. Therefore riparian forest buffers should be maintained or re-established adjacent and up gradient from water bodies through replanting or allowance of natural regeneration.

Seeding grass, grass and legumes, and sod

These measures are used on sites not susceptible to serious erosion. Seeding with a mixture of grass and legumes will give a quick, effective, and cheap soil protection. Sod may be used when a cover is required in a short period of time.

Kaitzbach (Dresden) - sod and jute mesh

The cross section of the Kaitzbach was widened. The new banks were covered with sod and subsequently covered with jute mesh to prevent erosion in case of a storm event. The jute mesh was integrated prior to the installation of fascines at the toe of the banks.

Figure 24 (left): Re-using of sod, jute mesh is still rolled in at the toe of banks
Figure 25 (right): jute mesh is rolled out to protect the just brought out sod from erosion, a dead fascines protects the toe, the jute mesh is fixed with willow stakes

Perennial herbaceous plants

Plant communities of riparian wildflowers, weeds, inundation grasses, and tall, herbaceous plants may be seeded or planted. Planting occurring in the dormant season involves rhizomes and shoots placed in holes or narrow trenches close to the average summer water level.

Live stakes

Cuttings from living branches (4.5 cm diameter minimum), that are inserted into the ground will root and leaf out. They are an alternative to planting rooted stock.

2.2.3 Measures enhancing continuity

(S) Removal of migration barriers

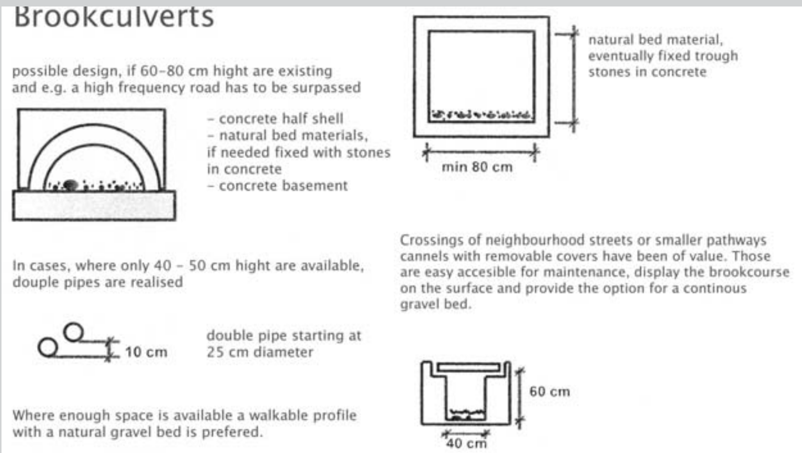
Barriers to migration include any obstacles that may interfere with, or prevent the upstream or downstream movement of fish or even invertebrates. These obstructions may include dams, culverts, and heavily engineered channels of concrete. Modification and/or removal of barriers can open up large sections of streams to fish populations (including spawning habitat) that was previously unreachable. Temporary migration barriers may be set up to block rapidly spreading species from reaching not yet fully rehabilitated sites.

Náhon (Chrudim) - Elimination of flow and migration barriers

In terms of an effective and consequent rehabilitation of riverine functions the old mill race (Náhon) was completely reshaped. Being a migration barrier on one hand and inhibiting riverine processes and riverine live on the other hand impoundments such as for driving the mill have been removed. Impoundment behind the old mill has been eliminated and will be used only occasionally and not lasting more than a few hours or a few days. Other weirs are to be completely removed.

Figure 26: Removal of migration barriere at the mill

Albisrieder Dorfbach, Brook Concept Zurich - Ecological enhancement of culverts



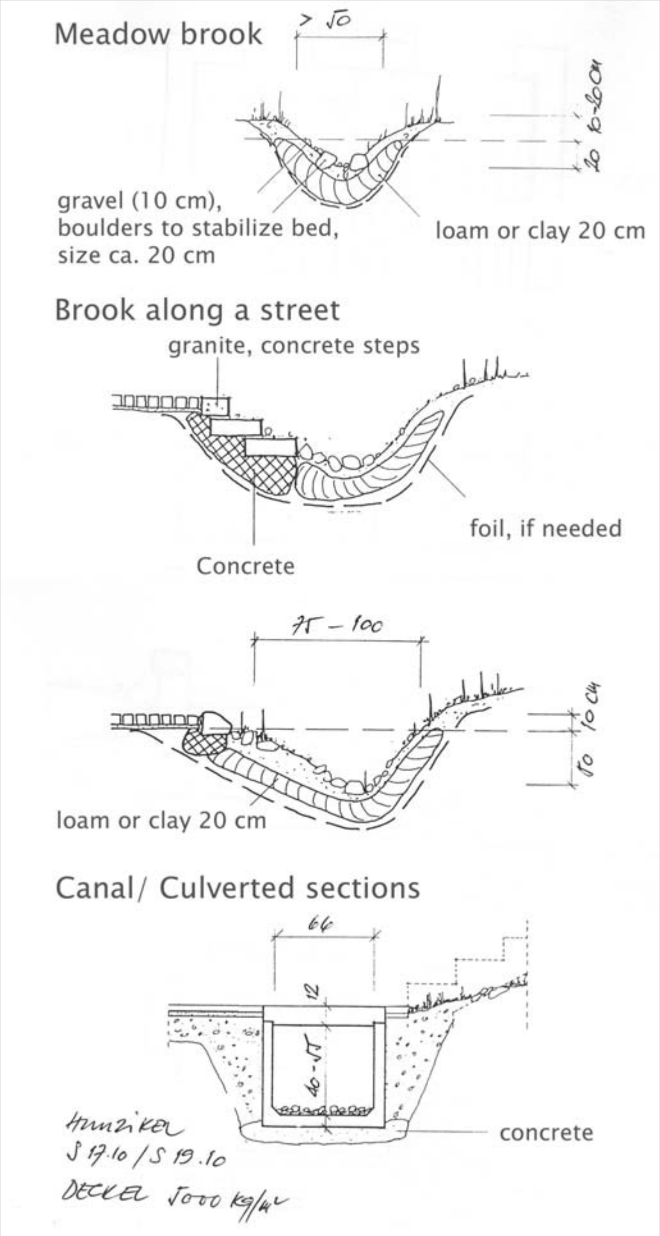
Due to urban land use pressure not all culverted river sections are daylighted. In such case culverted sections can be enhanced to improve ecological continuity for sections upstream. The brook concept in Zurich developed principles for various conditions.

Figure 27: Principles to enhance ecological continuity in culverted sections

(S) Daylighting of streambeds

Culverted or covered streams are to be opend up to enhance ecological continuity. New stream alignment should consider historical information as well as existing uses.

Albisreader Dorfbach, Brook Concept Zurich - Creation of new riverbeds in urban areas



During the last 20 years many small brooks have been daylighted in the City of Zurich. Where possible new brook courses have been designed, following their historical layout. Spatial constraints call for compromises in the design of new brook channels for daylighting. Whenever infrastructure had to be protected from infiltrating water, brook channels were lined with a clay/loam or even a foil bed, covered with natural bed material.

Figure 28: Constructive principles for new brook beds in spatially restricted areas
Figure 29: Dayligted Döltschibach, design is adapted to spacial availability

2.3 Improving Water Quality

(S) Combined sewer overflow source control

CSO source control reduces the quantity of pollutants entering the system. This includes control of illicit connections, street sweeping, catch basin cleaning, and storm water management measures that reduce or delay the volume of runoff entering the system. Too, measures to conserve water used in households will reduce loads on treatment plants.

La Chaudanne (Lyon) - Disconnecting waste water and stormwater sewer networks

CSO, the mayor problem at the Chaudanne, was solved by a partnership of convenience for inter-municipal basin management (SAGYRC). The surface and waste water systems have been partly separated. A storm water retaining, treatment and infiltration system was installed including sand and grit separator, three retention and infiltration basins as well as a sub surface filter system for fine material and organic matter separators. The system has been inaugurated in June 2003 disconnecting 20 ha of surface runoff from a 44 ha large urban area drained by a combined sewer network. In August 2003 a several years flood occurred and was successfully retained.

Figure 30: Separation of combined sewage channel

(S) Off-line storage of combined sewage

This type of storage involves the containment of combined sewage that normally would overflow and discharge to receiving rivers. Storage facilities are usually large underground tanks or tunnels. When flow capacity is once again available within the system, then the stored combined sewage is conveyed to the treatment facility.

Torre della Bella Monaca (Rom) - Mitigating CSO through a wetland treatment system

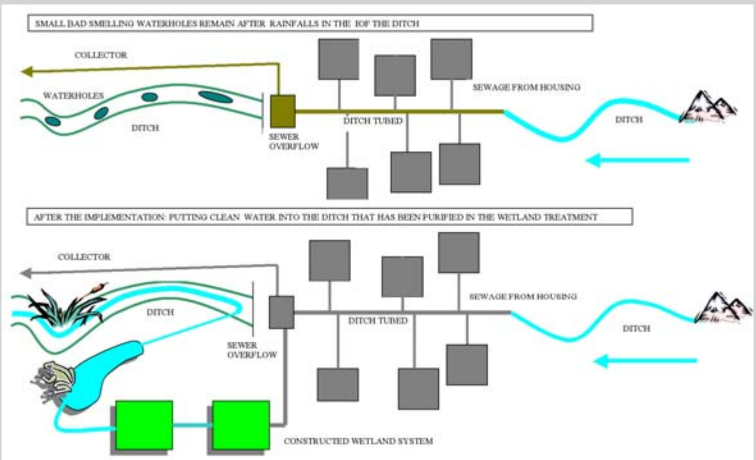


Figure 31: Schemata of wetland treatment plant

A wetland treatment plant had been installed for catching sewage overflows and treating it in detention basins, before discharging it into detention ponds and then into the Torre della bella Monaca ditch. The plant occupies an area of about 16,000 m², subdivided in 3000 m² public park, 5000 m² of constructed wetland sewage treatment basins (sub surface flow) and 3000 m² of ponds (free water system). It is situated 5 m below the park level and is framed by a steep slope, lined with hedges. The plant is visible from footpaths of the public park, but is not accessible for safety reasons.

Torre della Bella Monaca (Rom) - (continuing)

The ponds have been viewed with mixed feelings. Residents opinions reached from negative (e.g. „mosquito breeding places“) to very positive ((e.g. „new wildlife such as dragonflies, water birds, and waterfowl“). In order to increase the value of open space pond slopes that are too steep and made with slippery PVC will have to be flattened in future. Due to the steep slopes, inappropriate maintenance, shortage of (rain) water and vandalism (fire) only a few bushes have survived and need to be replaced. The scheme offers mitigation of CSO in circumstances, where source control is not possible.

Figure 32 (left): Treatment basin in construction
Figure 33 (right): Detention ponds two years after construction

(S) Avoiding siltation of gravel-bed-rivers

Necessary, where gravel-bed-rivers suffer from sediment deposit. Here natural hydromorphology needs to be taken into account. Often an adaptation of channel design can solve the problem by introduction of more natural hydraulic conditions. Especially in artificial and heavily modified waters hydromorphologic modelling can help to solve the problem. Silt related problems often result from increased erosion in the catchment area. Therefore in stream measures should be preceded by measures reducing the entry of sediment material into the river from urban and agricultural surfaces as well as from construction sites.

(S) Management of construction sites

Minimising erosion during construction activities results in the reduction of one of the major sources of sediments in urban areas. It not only results in faster re-establishment of vegetation, but also in an enhanced appearance. On sites susceptible to erosion attention should be paid to the layout of construction roads.

Oil/ Grit separators

Oil/Grit Separators are multi-chambered structures designed to remove course sediment and oils from storm water prior to delivery to a storm drain network. Separators are used as pre-treatment for infiltration Best Management Practices such as Porous Asphalt pavements, Modular Pavements or Infiltration Trenches. They are generally used on parking lots, on streets or other areas that receive vehicular traffic. Each separator would generally receive runoff from an area of less than one acre.

Grassy vegetative filter strips

A vegetated boundary characterised by uniform mild slopes. Filter strips may be used on down gradients of developed tracts or on impervious sites to trap sediment as well as sediment-borne and attached pollutants.

Grassed swales

Grassed swales are linear areas of grass, generally designed to convey runoff from one location to another. The main purpose of the swale, in addition to conveyance, is to trap suspended solids.

Sand filters, peat-sand filters

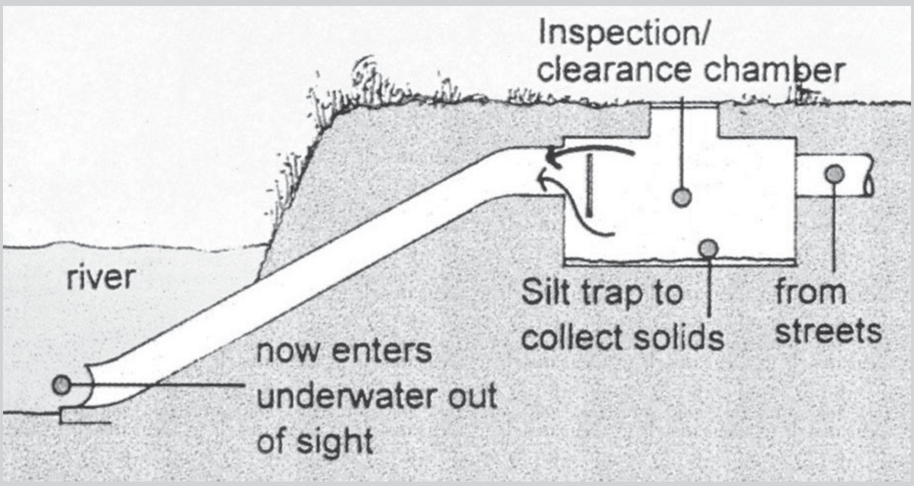
Sand filters are off-line devices designed to improve water quality by filtering the first flush of runoff from impervious surfaces. The device consists of a sediment chamber, where larger particles are settled out. Typically, sand filters are housed in a concrete box.

La Chaudanne (Lyon) - Sand and gravel filter / Grit separator

The system has been inaugurated in June 2003 disconnecting 20 ha of surface runoff from a 44 ha large urban area drained by a combined sewer network. The mechanical separator device was installed preceding a system of three retention and infiltration basins. This sediment deposit basin of 10 m 3 allows detaining at east a two months return period urban runoff flow to avoid transfer of the first very polluted flow to the detention basins. Runoff exceeding the limit of the concrete basin flushes through leaving only more or less coarse sediments. The first (upstream) basin is planted with fragmitae (reeds) that bio-accumulates heavy metals and will be periodically removed. An extensive network of roots and subsurface rhizomes facilitates infiltration.

Figure 34: Sand and grit separator of with overfall into the first of three detention and infiltration basins

Skerne River (Darlington) - Sub surface sediment trap



After removing 22 separate drains and storm water outfalls entering the river one central outfall was connected to a backwater preceded by a subsurface sediment trap.

Figure 35: Silt trap installed upstream the release into the lowest backwater

Temporary runoff diversions and chutes

Temporary flow diversion structures (such as gutters, drains, dikes, berms, swales, and graded pavement) are used to collect and divert storm water to prevent the contamination of runoff and receiving water. Storm water that is potentially contaminated can be directed to a treatment facility.

Silt fence and trapping devices

Silt fences are temporary structures used to prevent or minimise transport of sediment in storm water runoff that is leaving a construction site. They consist of a linear filter barrier constructed of synthetic filter fabric (geo-fabric), posts, and depending upon the strength of the fabric used, wire fencing for support.

Sediment basins

A barrier forms a sediment basin across a drainage way, causing an impoundment that detains water and drops out sediments. The size of the basin is calculated to store expected sediment yields of disturbed sites. Once a site is stabilised the basin may be put to another use.

Constructed wetlands (synonym: artificial wetland)

These facilities treat runoff by utilising the water-quality enhancement processes of sedimentation, filtration, adsorption, extended retention, as well as biological processes. Control of an adequate water level is essential.

Bioretention

A bioretention system is a multifunctional landscaped area that provides for the retention of a design storm and for water-quality improvement. They contain a soil aggregate of three feet depth and are drained underneath by a layer of crushed stone with an optional drainpipe. The surface is vegetated and improves water quality through infiltration and evapotranspiration. They also offer owners site enhancement benefits.

Anacostia River (Washington D.C.) - Bioretention (Chesapeake Bay Foundation, w. y)

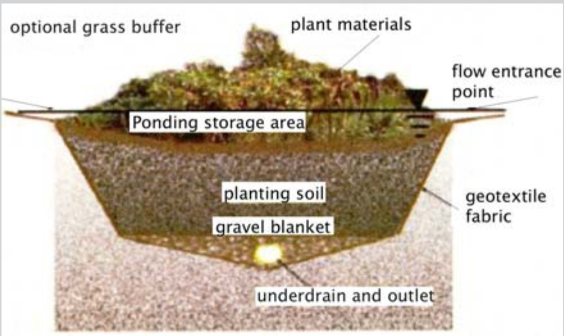


Figure 36: Diagram of a bioretention area

In the basin of the Anacostia River bioretention areas are promoted to hold, filter and infiltrate rainwater on private yards. Bioretention areas are created trough a bed of permeable material and are constructed depending on the characteristics of the run off, that is filtered. Engineered bioretention areas are 0,6 to 1,2 meters deep, about one to four square meters and constructed with successive layers of gravel, sand and mulch, under the top garden planting.

Hydroseeding and chemical stabilisation

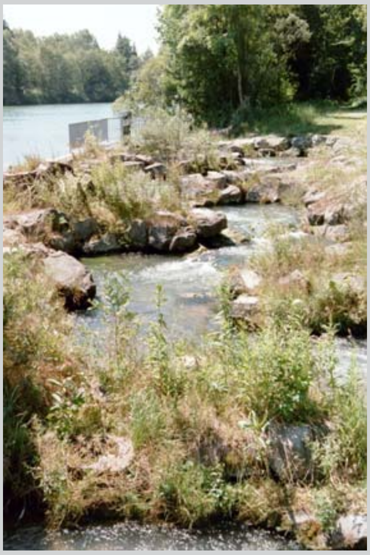
Hydroseeders are truck-mounted and enable the forced application of slurry of seed, water, fertiliser, soil conditioner and fibre mulch. Steep areas, and areas of vast scale, may be seeded and fertilised economically in just one operation. Chemical soil stabilisers may be added to the slurry to help prevent seed loss and erosion during germination.

2.4 Habitat improvement techniques

Fish ladders, fish passage improvement

This is a technique in which changes are made to the stream channel to bypass natural or manmade barriers, which obstruct the migration of fish to upstream areas to spawn. Fish passages provide access to upstream areas, habitat utilisation, and an improved fishery value.

Isar (Munich) - Fish ladders to bypass un-removable weirs



Not all of the existing weirs or drops along the Isar could be removed due to existing uses. Therefore fish passage improvements were installed, to enhance biological continuity.

Figure 37: Fish passage at the Isar, 2003

Boulder clusters

Boulders are strategically placed groups of large rock established along a channel bend in order to break up flows and to form scour pools used by juvenile fish as resting areas. They establish shelter for aquatic life and breeding areas. *Lunker structures*A crib wall of logs and rocks are embedded into the toe of the stream bank, creating a fore bay that extends over the water. Lunker structures combine toe stream bank protection to curb bank erosion. They also serve as shelter to aquatic life.

Restocking fish fauna

Hydromorphologic and water quality improvements are to provide habitat for fish. In some cases, a restocking of native, fish may be done. Potential for re-colonisation may be tested with breeding-boxes.

Removal of invasive species

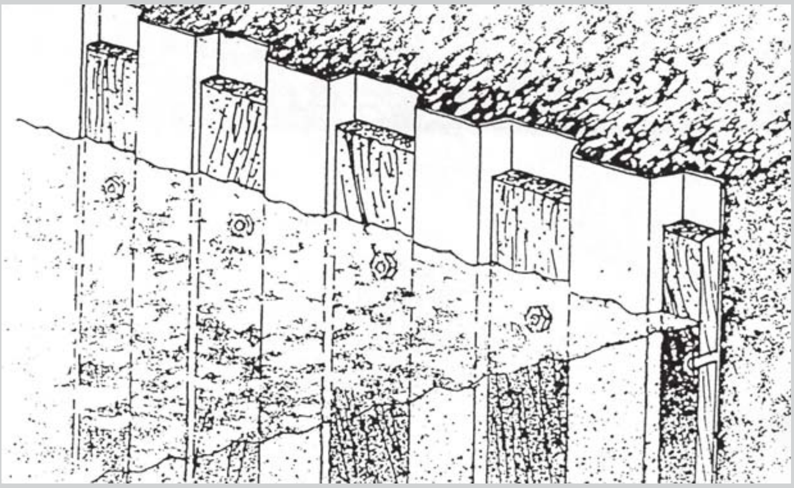
Invasive species often suppress native species from their natural location and thus reduce habitat and habitat qualities. Consequently invasive exotic flora should be cut, dug, or pulled out. Volunteers can do this to minimize costs. Examples are the „Multiflora Rose“ choking native vegetation in the Don Valley in Toronto and invasive weeds that impede the flow of small streams in Germany.

Habitat enhancement of harbours

Harbours are one of the most restricted areas for ecological in-stream enhancement. Specialised techniques, such as swim-pontons and woodpiles along sheet pile walls can be used to mitigate lack of habitat structure and provide for shelter, cover and spawning structures for invertebrates as well as fish. Swim-pontons respectively floating reed banks provide for shelter, shade and spawning possibilities, where no riverbank enhancement for fish habitat is possible.

Elbe/ harbour basin (Hamburg) - Ecological improvement of artificial tidal habitat (Freie und Hansestadt Hamburg, Umweltbehörde 1995)

Innovative management practices were employed to improve biodiversity in a former harbour area of„Hafen City“ in Hamburg. For this purpose a management plan „Gewässerökologischer Strukturplan für den Hamburger Hafen und Tide-Elbe in Hamburg“ for ecological enhancement was published. Some harbour enhancement took place in connection with the creation of a public park. By partly filling the head of an abandoned harbour basin space was created for a new public park in connection with an adjacent industrial brown field. Instead of a vertical bank, a sloped riparian bank was graded with a slope of 20:1. Aquatic habitat was created, providing shallow water zones as rest areas for fish of the connected River Elbe. The bank was re-vegetated with submerged plants and zonal planting of reeds as well as an initial softwood zone.



Additionally, vertical insertions of wooden planks were attached to remaining sheet piling along the sides of the harbour to enhance diversity and to provide niches within the tidal habitat. The wooden planks provide holes, to be used by invertebrates as habitat. The success of this measure is still being tested.

Swim-pontons offer a flexible option to enhance habitat structure in harbours, impoundments and lakes. Swim-pontons with vegetation provide for spawning and sheltered habitat. The roots of the plants penetrate the pontons and then are used by invertebrates and leaf-spawning fish. Plastic boxes with a permeable surface, hung in the pontons and filled with gravel, are colonized by diverse invertebrates and provide a basis for macrozoobenthos. Swim-pontons are best installed, where little ship traffic takes place. Other suggested measures included the placement of gravel into rock riprap and vegetation revetment. Today the ecologically enhanced harbour basin „Hakenbecken“ serves as a model for similar facilities.

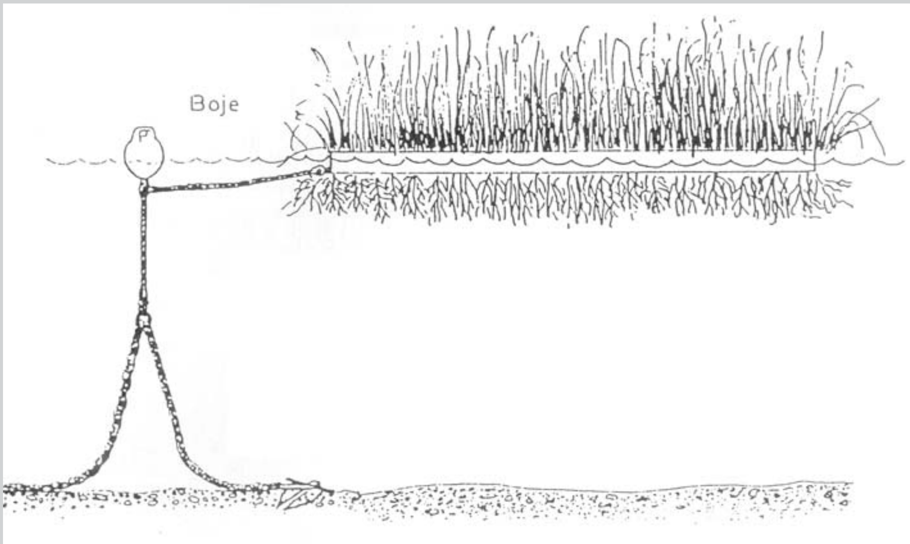


Figure 38 (top): Sketch of wooden planks in sheet pile walls
Figure 39 (bottom): Sketch of swim-pontons with reed vegetation

2.5 Techniques incorporating features to improve public health and safety

(S) Flood proofing of structures/Flood proofing against water pollution

New buildings that have been permitted to be constructed on the floodplains should be built on stilts in order to avoid the reduction of flood storage capacities. Existing structures should be flood proofed to include provisions for intentional flooding of spaces below flood stages to balance internal and external pressure. Openings and doors should be reinforced. Structures should be equipped to be flooding resistant hence having sufficient strength to withstand the pressure and the impacts of floating debris. Below flood level oil tanks should be anchored to prevent flotation and leakage. Sewer lines should be equipped with flood proof lids and sewage treatment plants should be flood proofed. The storage of materials that are toxic, explosive when exposed to water, or buoyant (drift solids) should be prohibited.

(S) Flood Plain retention

Wherever flood control is needed, floodplain retention should be considered to protect urban areas downstream. Consequently along canalised rivers wherever space becomes available, floodplains should be established. New floodplains not only provide for flood control, but will also enhance habitat diversity, aesthetics and amenity values. Within areas of high land uses pressure, floodplains should be designated for land uses with low flood damage potential (e.g. park area).

Lower Rhine (Arnhem) - Dike relocation as result of a joint flood control programme

Main objective of the over 1500 m Bakenhof Dike realignment of was to mitigate the river’s bottleneck situation at Arnhem, located near the confluence of IJssel and Lower Rhine. The new levee was setback from the river by an additional 200 m. This project should be seen in conjunction with the inland replacement of the Pleidijk (IJssel-dike near Westervoort), which is being carried out to maintain the water flow division between the Rhine and the IJssel rivers. Through relocation of the dike and by restructuring the forelands, the high water level is locally reduced by as much as 70 cm, in ideal circumstances.

Works of Rijkswaterstaat, Dir. Oost-Nederland, consist of the restoration of an old IJssel bend, and a new secondary channel. This secondary channel was designed to receive water only at middle water level from the downstream connection with the summer bed. During flood events, the channel is completely submerged and thereby increases the flood discharge capacity, lowering the high water level.

Connecting ecological valuable flood plains and lands has established habitat connections between formerly isolated areas. Linking Meinerswijk and the Huissense flood plain is to assist the migration of small animals. This rehabilitation and flood prevention project (implemented between April 2000 to June 2003) was the first of series of „Room for the River“ projects to come. By creating more storage space in the flood plain, over 6,000,000 m² of additional retention area will be established. At present, the LowerRhine, at Lobith, can cope with a discharge of 15,000 m³ per second. In the future, this will have to be increased to 16,000 or even 18,000 m³ per second. Co-operation in the larger region will achieve this.

Dikes, levees, floodwalls

Dikes and levies should not be built in the „open floodway“ district. Wherever possible, existing levies should be set back to give a river more space for flooding. Temporary floodwalls to divert floodwater flows can protect critical sites. In areas that are subject to tidal flooding, dikes need to be equipped with tidal gates or backwater valves.

Isar, Munich, Germany - Ecological dike maintenance

The levees along the Isar protect urban settlement from flooding. Today those levees provide ground for mature trees, which unfortunately endanger levees' safety. When the ground of levees is soaked, trees can overturn and create breaches. As a compromise, and to save the vegetation concrete cores have been placed in the levees for stabilisation. In some cases, when enough space is available, a second levee is placed land inward from the first one to increase safety.

Figure 40: Principe sketchto restore dikes with trees in an ecological manner

(S) Emergency management

Emergency management includes measures as emergency access and flood warning systems etc. Structures should be accessible by elevated access ramps and catwalks. For structures with high intensity uses access ramps need to be suitable to be used by emergency vehicles. Flood warning systems for communities should be developed to be timely, accurate and neighbourhood specific.

(S) Safe bank design

Lowering or terracing banks provides for safe interaction with the water body since risk of falling is minimised, sudden inundation of water in case of floods is avoided. Where lowering of banks is not possible railings, pollards or similar measures should provide against falling in.

Quaggy River (London)

After being canalised in a rectangular concrete channel the Quaggy River has been released and reshaped according to historic maps. To increase flood conveyance and for reasons of public safety the new flood way was designed within a seven meters corridor with shallow banks. Thus a „falling into the channel“ has been made impossible. Safe interaction with the river is enabled through free access to the semi natural channel.

Figure 41: Safety design of a river channel benefiting natural features and interaction

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Images:

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Figure 4,5, 27-29:	*Entsorgung + Recycling Zurich*
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Figure 16 - 23:	*Conseil général du Rhône (section CATER 69 - Rhône Insertion Environnement)*
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Figure 31-33:	*Water Design, ROM*
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Figure 40:	*Landeshauptstadt München, Wasserwirtschaftsamt München (Flyer, without year): Neues Leben für die Isar. Munich.*

Urban River Basin Enhancement Methods

REVITALISATION OF THE LJUBLJANICA RIVER

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INTRODUCTION

The relationship between a developing urban environment and water is manifold. Water is the source of life and a city cannot function properly without a modern and safe water supply. However, water may pose a direct threat to human lives by ways of pollution and floods. Furthermore, water is a major basis for an array of economic civic activities: shipping, sailing, fishing and the use of water force. And importantly, water in built-up city areas provides a means of staying in touch with nature and enables a unique design of man-friendly urban environment.

In spatial planning, a proper solution to crossing the gap between surface water regimes and urbanization is necessary. A water regime with its flow dynamics demands its space; however the city with its own demands of development may want to narrow that very space as much as possible. Simultaneously, urbanisation modifies discharge conditions, which consequently leads to damages imposed on the city during flood events. Ecologically affected water environment fails to provide clear water and friendly environment, bearing an indirect effect on urban life. A modern approach to sustainable development, specified by the Water Framework Directive calls for solutions enabling the development of a safe urban environment and an enhanced development of water regime as well as the possibility of achieving good conditions of water bodies.

The present paper aims at presenting the urban Ljubljanica River from the Ambrož Square to the Špica with the Gradaščica watercourse to the bridge in Riharjeva Street and the Mali Graben, Figure 1, set as case examples of good practice in managing urban watercourse regimes. The Ljubljanica and Gradaščica watercourses were chosen due to their originally beautiful, man-friendly and functionally arranged banks designed by architect Jožef Plečnik. Standing out are the sluice gate, fish market, the Three Bridges and embankment around the Three Bridges, Trnovo Pier and the Gradaščica embankment between the Trnovo church and the bridge on Riharjeva Street. The Ljubljanica water regime on the particular reach is managed by a gate at the Ambrož Square that regulates the low-flow channel. Without the gate, during periods of low flow the flow in the paved channel charged with urban alluvial deposits would have been narrow and shallow. The Mali Graben has been chosen because of its transversal structures that enhance channel wateriness and form river pools and riffles.

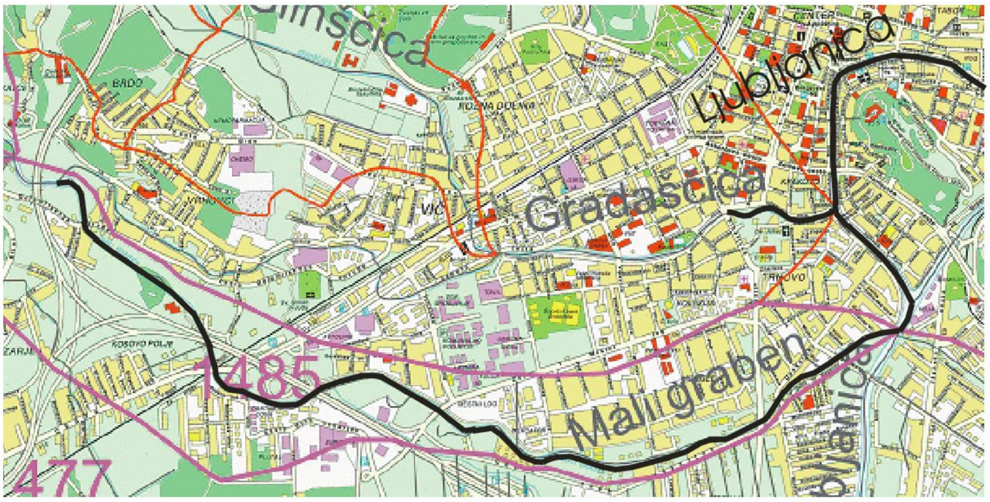

Figure 1. Streams and the surrounding area of the case study site.

HISTORICAL OVERVIEW OF WATER-RELATED ISSUES

The development of the city core of Ljubljana and the Ljubljanica River management dates back to the time of ancient Greece and Rome with the building of Emona, Figure 2. Unfortunately, there are no maps from the time available, however, the position of the city was harmonised with the position and water regime of the then watercourses of the Ljubljanica and Gradaščica that were equipped with structures for navigation and bridges.

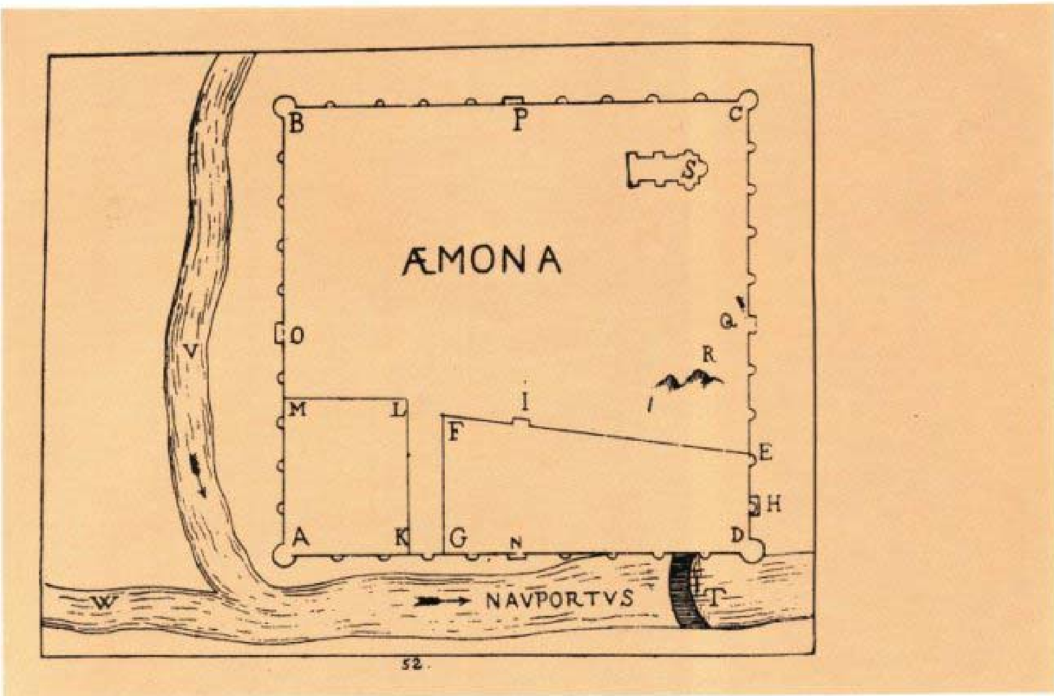

Figure 2. Emona; Source: Korošec (1991).

Regarding water structures, the medieval Ljubljana boasted a characteristic rake placed transversally to the watercourse among the fortified city walls, Figure 3, Korošec 1991. In addition to the rake, there is a ditch between the castle hill and the Ljubljanica, as seen on the map. Ljubljana spread to both river banks, and consequently, the flood plain area was narrowed with houses, fortified banks, mill dams and fortification objects, Uhlir 1956.

Additionally, owing to occasional flood events, the narrow and shallow channel could not carry the flood water. Major floods were registered in 1190, 1537, and 1599. A first greater intervention into the Ljubljanica water regime in the respective section was the building of the Grubar channel that diverted the flood flow past the city core. The building was accompanied by high costs regarding compensation of purchase of land and unexpected works caused by geological soil composition. The building took place between 1773 and 1780. The preparations and discussions of the variants of possible interventions date back to 1769, when a decree of Empress Mary Theresa was issued, providing the funds for the building. The proposition of demolishing the dams on the Ljubljanica River and expanding the channel in the city failed to receive a proper support of the city and the States. The foreseen changes in the channel of the urban Ljubljanica, otherwise predicted as part of a wide-ranging project, later remained unrealized due to lack of means. The works, i.e. related to dredging and removal of mill dams, were executed as late as in the period of 1823–27, Uhlir 1956. The position of riparian structures is evident from Austrian army maps dating back to the end of XVIII century (1763–1787), Figure 4.

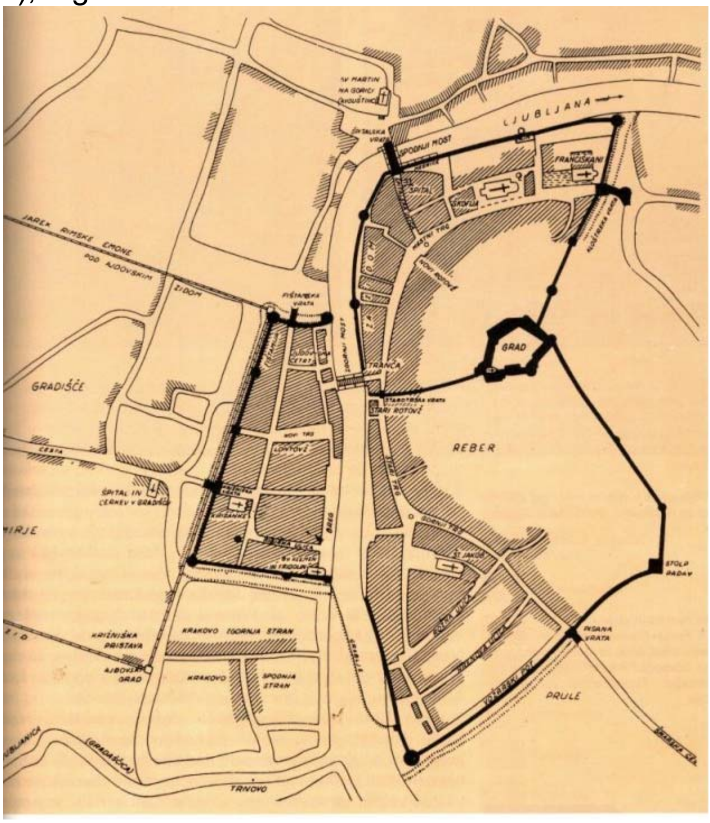

Figure 3. Ljubljana in the 16 th and 17 th centuries; Source: Korošec (1991).

Figure 4. Austrian army map of Ljubljana; Source: Rajšp and Ficko (1996).

Navigation on the Ljubljanica River was essential in the development of the medieval Ljubljana, Figures 5 and 6 (Korošec 1991, Holz 1997). Navigation was first mentioned in 1092, Uhlir 1956. Navigational rights were under princely jurisdiction and an important source of income. With the arrival of railway in the mid-19th century, navigation lost its meaning and in fact died out completely. However, street names in Trnovo (Little and Great Boat St.) and embankment names (Trnovo Pier) still bear witness of the importance of navigation.

Figure 5. Navigation on the Ljubljanica River in the beginning of the 19th century; Source: Korošec (1991).

Figure 6. Illustration of the celebrations on the Ljubljanica River in honour of Crown in 1819; Source: Holz (1997).

The Ljubljana city development was badly interrupted by the 1895 earthquake that caused severe damage but admittedly enabled an urban reconstruction of the city, which gradually transformed from an extended village into a modern European city (Uhlir 1957). Following a successful building of waterworks and several public facilities, the rapidly evolving city came across its first problems owing to the regime of its watercourses. In 1924, there were great floods of the Gradaščica in the Vič area in the Ljubljana suburbs. Due to settlement needs there were extensive works on the Gradaščica regulation, diverting the water into the Mali Graben channel and building levees in the area between the Gradaščica channel and Tržaška Street. The works continued with regulation works on the Ljubljanica. The Ljubljanica River training was additionally enhanced after the 1933 flood that damaged the city core as well. An integral channel fortification encompassed also regulation works of the urban sewage system that put a stop to a free discharge into the channel, causing unpleasant smells with low water level.

Bank training of the urban Ljubljanica was included into the urban plan of the after-earthquake restoration of Ljubljana. The training was dictated by the developing city core in the 19th century and by the completed regulation works. Channel dredging and loading of the excavated material onto the banks formed a deep channel with steep banks. The basic design for the river training with vertical walls was proposed by the Vienna architect Keller in 1913, which followed the example of a similar regulation of the Wienfluss river in the narrow city centre of Vienna. In 1929, architect Jožef Plečnik undertook the design of construction works on the Ljubljanica banks; he managed to change the roughly shaped channel with vertical walls into a friendly and humane environment, Krečič, 1992. Plečnik used every opportunity to enhance the regulation works and improve the contact of man and nature, figures 7 and 8.

Figure 7. Pedestrian-friendly bank construction made by Plečnik

Figure 8. Three Bridges with river bank access and development made by Plečnik

After World War II works on the gate at the Ambrož Square came to an end and no further alterations followed, with the exception of groundwater discharge from the Cankarjev Dom area, figure 9. The gate fulfill concrete stream channel with water and instead shallow water flow with visible concrete bottom, navigable water course and water body deep more than few meters was established. Volume of the water increases tremendously, figure 8.

Figure 9. The gate on Ambrož Square

The gate on the Ambrož Square is also important with regard to management of surface waters and groundwater regime upstream of Ljubljana moor. The Ljubljana moor, a large flat area with an artesian aquifer covered by 20 meters of unconsolidated clay, is highly vulnerable to changes in water regime. Lowering the in stream water level of the Ljubljanica river could cause bank slides and instability of the riverbank in the Ljubljana moor area. Lower in stream water level and indirectly a lower artesian groundwater pressure that caused consolidation of the clay layer, subsidence of land surface of the large flood area.

Worsening of water quality in the Ljubljanica due to urbanization and industrialization of the watershed marked the-1950–1990 period. The water failed to meet bathing water criteria and consequently the Špica baths closed down. Additionally, navigation on the river disappeared with the exception of amateur boating.

Additionally, small-sized watercourses at the city edge were polluted; open sewage system had changed them into a site of filth and rats. Thus, a much needed regulation of the urban Gradaščica and Glinščica channels followed in 1974. Today, their channels are narrowed into tight channels made of concrete and rather resemble an open sewage system as opposed to a natural watercourse.

What remained was fishing managed by fishing societies. Owing to the demands and needs of the Dolomiti fishing society, a successful revitalization of the Mali Graben channel with transversal dams was carried out. The dams raised the water level in the channel, increased its volume, and formed several river pools and rapids, and thereby enabled an increase of fish population by 50 %.

After 1990, water quality in the Ljubljanica River started to improve, this being the basic condition for several riparian activities, especially recreational activities. An improved water quality has enabled navigation for tourist needs, which has been developing gradually. The problem remains the insufficient bank regulation and a general disorganization of activities.

3 STATE OF THE LJUBLJANICA, GRADAŠČICA AND MALI GRABEN WATERCOURSES

For the reaches of the Ljubljanica River from the Špica area to the gates at the Ambrož Square an urban regulation of the watercourse is characteristic. The urban regulation has been increasing, following the natural pre-urban river with natural banks and abundance of bank vegetation, park-like setting regulations in the Trnovo Pier area, putting into the foreground the natural watercourse, and finally evolving into a completely urban watercourse with high density of bank built-up areas downstream the Zois Bridge. Photos of presented sections are available on http://ksh.fgg.uni-lj.si/urbemdatasi/.

Plečnik's regulation of the Gradaščica River reaches from the confluence up to the bridge on Grohar Street. The Mali Graben watercourse runs from the weir on Bokalce downstream towards the confluence with the Ljubljanica River in The Špica area, Figure 1.

3.1 ALONG THE LJUBLJANICA RIVER

3.1.1 Špica and Trnovo Pier Sections

The Špica area is intended for mooring of an increased number of river boats. At the section, river banks are grassy or ordered with natural rocks. They reach to the water level and are equipped with walking paths and benches. The left bank has been arranged as a tree-lined promenading path.

The Trnovo Pier is a major feature of urban planning and a constituent part of the green system of Ljubljana. It boasts a characteristic avenue planted with trees on the left bank, while the opposite bank is grassy with a pathway. At the ending section, the urban Gradaščica flows into the Ljubljanica River. The Trnovo Pier was regulated by architect Jožef Plečnik in 1932 and presents an extraordinarily beautiful, friendly and functional spatial arrangement. The wide steps enable a direct access and contact with water, as well as the possibility of spending time on the river banks and a pleasant way of having a rest or walk. High trees give an additional protection against sun and are of enjoyable nature.

3.1.2 Urban Ljubljanica Section

The urban Ljubljanica section downstream of the Zois Bridge differs from the Špica and the Trnovo Pier in having a distinctive concrete river bed with high walls. In the first section, the highly regulated watercourse beds are still grassy and equipped with tree-lined arrangements and benches. Along the left and right banks, respectively, there are pavements and traffic ways.

In the Cobblers' Bridge area, there are no more high grassy watercourse banks. The concrete channel walls terminate as a fence, on the left and right banks there are tree-lined arrangements all the way to the Three Bridges that finishes off on the right river bank with the colonnade of the Ljubljana market. The concrete walls are decorated with rock materials, and intermittent terraces were built that enable the growth of decorative plants and provide a cover-up for the grey concrete walls. Restaurants built into the walls of the banks and set-up floating pontoons enable further contact between the city and river.

The market is of exceptional beauty. Plečnik put the fish market into the vertical bank and lowered it to the water level. The visitors are given a fine view of the by-passing river.

Downstream of the Dragon Bridge the channel and grassiness of the banks are similar to the ones of the Zois and Cobblers' Bridges. Somewhat lower walls of the concrete channel were revitalised with grassy banks, tree-lined arrangements and benches. Similar is the situation downstream of the Ambrož Bridge gates.

A study entitled "Arrangement of the riparian space of the Ljubljanica River from the Barje marshes to the Sava River" (LUZ d.d., 1997) has included for the Špica area, Trnovo Pier, and the urban Ljubljanica River an overview of proposals for arrangements and use, a complex analysis of riparian space and a description of main characteristics of the river reaches under consideration. On the basis of identification of problems (maintenance, planning, and arrangements, deterioration of riparian space, river as public good), conditions for implementation of programmes into riparian space, and professional bases for an integrated planning the study proposed suggestions for planning the riparian space. It gives mapping resources, including the problem map (inaccessible watercourse banks, disconnectedness of the river corridor, low amenity value of the hinterland, disuse, improper public utilities, and ecologically and spatially degraded space of the river corridor).

3.2 ALONG THE GRADAŠČICA

Plečnik's regulation of the Gradaščica reaches from the confluence up to the bridge on Grohar Street. The lower section from the confluence to the Trnovo Church is strongly fortified with a concrete channel and vertical walls. Peculiar are the walking zone in Eipprova Street at the right bank lined with chestnuts.

The walking path on the left bank of the Gradaščica from the Trnovo Church to the bridge on Grohar Street is an example of a simple and friendly arrangement, enabling a direct access to the water. The water quality has gradually enhanced, and a revitalisation of the stream, including the removal of concrete lining, has been foreseen.

3.3 ALONG THE MALI GRABEN

3.3.1 Kozarje Section

The Mali Graben watercourse runs from the dam on Bokalce downstream towards Dolgi most passing the areas of Kozarje and Češminj. In the respective section, the watercourse is fairly wide, this being due to open space surrounding it, and is not limited by built structures and infrastructure connections in its proximity. Land use of riparian areas along the Mali Graben watercourse in the Bokalci–Dolgi most section is fairly agricultural. Upper riparian vegetation is well preserved and in mature condition. Here and there the riparian vegetation develops into a belt of hinterland vegetation. The banks of the watercourse are in their natural condition overgrown with riparian vegetation (in sections overgrown completely). In Bokalce in certain sections downstream they are fortified with massive rocks. The streambed is natural. Mud and large particles of alluvial deposits prevail. Water management measures in the form of stone weirs are noticeable that were carried out in the course of stream stabilization. In some sections, watercourse banks are due to dense riparian vegetation hard of access.

3.3.2 Dolgi Most Section

In the Dolgi most area the Mali Graben watercourse is crossed by three anthropogenic (man-made) corridors: the south Ljubljana ring, the regional road Ljubljana–Vrhnika and Ljubljana–Koper railway. From the crossings downstream along both banks of the Mali Graben corridor, a residence area has been under development. The watercourse corridor is substantially narrower, upper riparian vegetation is removed completely. The banks are grassy and overgrown with low riparian vegetation. The preserved hinterland vegetation is in mature state. Downstream the watercourse corridor is widened again; the overgrowth is extensive in both banks. River bottom is in natural condition, mud is in prevalence. There are some rocky ground thresholds. The corridor is crossed in the respective section by two street corridors, Lipan Street and the south ring. Watercourse banks are partly accessible via fishing paths and stands.

3.3.5 Mestni Log Section

In the Mestni log area of the Bonifacija, Murgle and Sibirija settlements the Mali Graben corridor is narrower. The riparian areas of the left and right banks take up open space and built structures, mainly individual residential buildings and traffic infrastructure. Along the left bank at Bonifacija there is in the immediate proximity of the watercourse of the major town planning features, a constituent part of the green system of Ljubljana and a prominent recreational area of the local inhabitants, namely the “pot” (Path of Remembrance and Comradeship). The bank boasts along the Path of Remembrance and Comradeship well-developed riparian vegetation, overgrowing the watercourse channel. Hinterland vegetation was removed during the building of settlements on both watercourse banks. The stream has natural mud bottom, in parts reinforced with transversal ground thresholds. Due to its dense riparian vegetation, the watercourse is hard of access and only in places functionally connected to the Path. The watercourse corridor widens once more downstream from the Murgle, where the dense vegetation of mature state partly overgrows the watercourse. Hinterland vegetation is well spread as well. In places, the hinterland and partly the riparian vegetation is intermittent due to land plots of individual residential objects, otherwise the riparian areas are mostly in the process of overgrowing. The banks are unmanaged, poorly accessible and left to natural succession.

The Path of Remembrance and Comradeship. Not so much hidden as impossible to take in at a single glance, this 30 km circuit of marked trails threading through Ljubljana's outskirts is both a reminder of history and a living recreational area. Numerous signposts and plaques reading "POT" (as in *Pot spominov in tovarištva*) mark the place where Ljubljana's World War II Italian occupiers erected a barbed wire barrier, intending to cut the city off from the outside world and choke its resistance movement. Now a very popular promenading and cycling path, the POT encompasses important sights like Žale Cemetery and Fužine Castle, the green slopes of Mostec and Golovec, suburban-industrial areas, and broad tracts of scenic countryside.

3.3.3 Trnovo Section

For the Mali Graben flow in the south ring section into the city centre towards the Mali Graben flow into the Ljubljanica a narrower river corridor with dense riparian vegetation is characteristic. Land use of riparian areas involves settlements of individual residential houses with private gardens reaching to the watercourse bank and disconnecting riparian vegetation. There is hardly any hinterland vegetation in the section with the exception of the Mesarica area, which boasts well developed small allotments. The river bottom is natural and mostly muddy, the banks are grassy and partly overgrown with riparian vegetation. Watercourse access in the section is mostly limited by private ownership of land.

3. 3. 4 State of Water Body after Implementation (according to Water Framework Directive)

According to the EU directive, evaluation of the ecological state of a specific water body calls for determination of the biological state, taking into account characteristic living structures in water ecosystems, namely in phytoplankton, macrophytes, phytobenthos, ground invertebrate fauna, and fish communities. The project included the valuation of the biological state in the Ljubljanica in urban environment and in the Mali Graben, and that after the measures carried out in certain sections of the watercourses. The state of the Ljubljanica River was assessed as poor according to its ecological status, considering biological, physical, and chemical as well as hydromorphological parameters. The microbiological parameters and parameters needed for estimating the bathing water criteria are even poorer and fall into the lowest category (3), failing to meet bathing water criteria altogether. In comparison to the Ljubljanica, the ecological state in the Mali Graben is one level higher, and demonstrating partly changed ecological status (moderate after revitalisation).

By way of a detailed analysis of living structures in the mentioned water bodies it can be established that the state of phytoplankton, macrophytes, phytobethos and fish communities is fairly good, however changed (i.e. moderate) in ground invertebrate fauna. Due to unfit hydrological conditions, there is no typical phytoplankton community in the Mali Graben, while other communities demonstrate a good state of water body.

The general chemical state in the Mali Graben is one level better than the one in the Ljubljanica (poor). Due to unregulated communal water treatment there are high contents of organic material in the water, especially critical in the Ljubljanica are some heavy metals in sediments and, according to the specific synthetic conditions, their state is considered bad. None of the chosen water bodies meets bathing water criteria needs, since the parameter values are exceeded; the inadmissible microbiological parameters stand out considerably, namely the high E. coli index, physical and chemical parameters and other substances indicating pollution, namely heavy metals and other pathogens.

A detailed overview of the state of communities in the Ljubljanica River may show the following: in the community of major water invertebrates, there is a prevalence of indicators of organic pollution, therefore – as mentioned before – the state of the Ljubljanica is moderate regarding invertebrates. Characteristic taxa are *Polycelis* sp., *Lumbriculidae, Naididae, Tubificidae, Enchytreidae, Eiseniella tetraedra*, some *Ephemeroptera*, and *Trichoptera* as well as a frequent occurrence of *Chironomidae*, among them *Orthocladinae* and genus *Chironomus*. The riverbed is overgrown by typical tree species, among them the frequent *Alnus* sp., *Salix* spp. and humid vegetation of *Iris pseudacorus*, *Sagittaria sagitifolia*, *Myosotis palustris*. There is an abundance of submerse vegetation communities, including filamentous algae e. g. *Cladophora* sp. and macrophytes, respectively. The most frequent among them are *Batrachium* spp., *Berula erecta*, *Callitriche* sp., *Lemna minor*, *Nuphar luteum*, *Potamogeton* spp., *P. natans*, *Lemna minor*, *Elodea canadensis*, *Hippuris vulgaris* etc.

3. 3. 4. 1 Fish Species Found in the Mali Graben

The regulation works in the Mali graben were carried out between 1984 and 1986. There were several thresholds built in the river, however no walls made of concrete were built and the living conditions remained favourable, bringing but a few changes for fish species. Table 1 lists the fish species found in the Mali Graben today. Table 1. Fish Species in the Mali Graben.

Class/Order	Common name
Barbus barbus	barb
Barbus balcanicus	
Carassius carassius	crucian carp
Chondrostoma nasus	nase
Cottus gobio	sculpin
Cyprinus carpio	common carp
Esox lucius	northern pike
Eudontomyzon mariae	Ukrainian brook lamprey
Gobio gobio	gudgeon
Hucho hucho	Danube salmon
Lepomis gibbosus	pumpkinseed sunfish
Leuciscus cephalus	chub
Oncorhynchus mykiss	rainbow trout
Perca fluviatilis	European perch
Phoxinus phoxinus	minnow
Rutilus rutilus	roach
Rutilus pigus virgo	Danube roach
Salmo trutta m. *fario*	brown trout
Scardinius erythrophthalmus	rudd
Thymallus thymallus	graylin
Tinca tinca	tench
Cobitis elongatoides	Danubian loach
Vimba vimba carinata	
Abramis brama	common bream
Alburnoides bipunctatus	chub
Hypochthalmychthis nobilis	
Lota lota	burbot
Rhodeus sericeus amarus	bitterling
Stizostedion lucioperca	pike-perch
Silurus glanis	Wels catfish

The catch of the nase (*Chondrostoma nasus*) and of the Danube roach (*Rutilus pigus virgo*) is presented (Figures 10 and 11). Both species are frequent in the total catch and of high interest. The catch prior and after the regulation is shown.

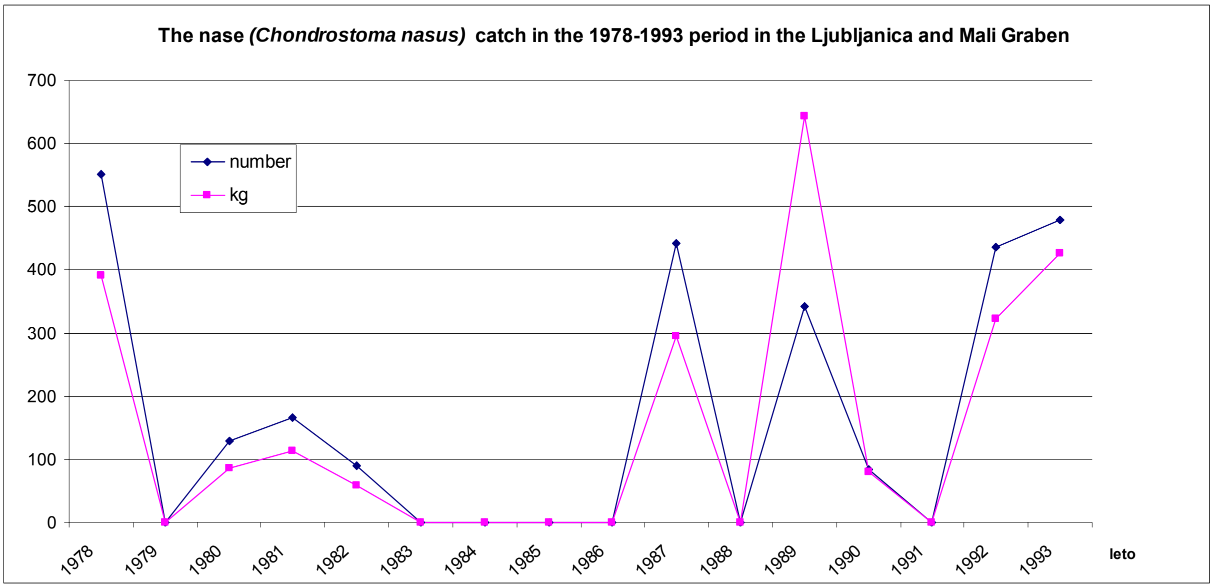

Figure 10. Catch of the nase fish population in the Mali Graben.

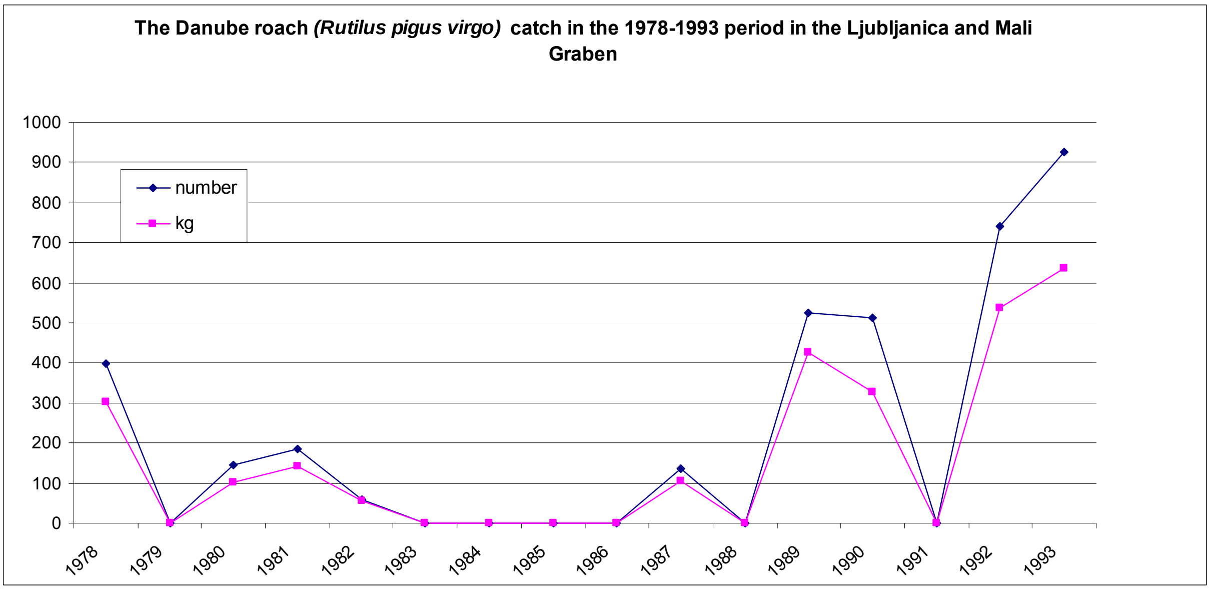

Figure 11. Catch of the Danube roach fish population in the Mali Graben.

4 SEWAGE SYSTEM DEVELOPMENT IN LJUBLJANA

In the area of Ljubljana, the first water supply was managed by the Roman city (*castrum*) of Emona. Water supply needs to be considered in an integrated manner, i.e. with regard to the water source – distribution system – as well as drainage and wastewater treatment, and it can be established that Emona was a well managed city. The water source was located in Rožnik outside the building area without the influence of urban activities, the drainage was channelled into the Ljubljanica (by way of *cloaca* sewers) without exceeding the self-cleansing ability of the river.

Figure 12. Sewage System of Emona; Source: Kolar (1983).

Regarding water supply, the medieval Ljubljana was poorly managed. Water was gained from the wells situated in courtyards where waste water was also discharged. Diseases were common. Exceptions are the remains of the Roman aqueduct, the Hercules well in the Levstik Square of today, which had water directed from Golovec (Volovec), as well as the well in the garden of the Benedictine monastery in what is today Congress Square, also the well at Castle Road is worth mentioning.

In 1890, when the Ljubljana water system was built (much of it is still in function today), the city had 900 houses and about 30,000 inhabitants. The more important citizens, in charge of decisions regarding development, were schooled in Prague and Vienna, and they brought back ideas of broader scope. Admittedly, water supply was one of the first meticulously inspected and executed development decisions. Namely, groundwater pumping of the plain Ljubljansko polje was one of the six alternative solutions based on observations, measurements and analyses carried out in the course of 10 years.

According to merit, the most deserving were the then mayor of Ljubljana Ivan Hribar, Prof. Dyonis Stuhr, who reviewed the design of the Ljubljana plumbing system, and architect Janez Vladimir Hrasky.

Ivan Hribar was mayor of Ljubljana between 1896 and 1910. His contribution was of high importance due to the development of the city that somehow coincided with the general restoration works following the 1895 earthquake of catastrophic proportions.

His inspiration came from the travels he made in his youth and his wish was that the city and its inhabitants would fit into the west European space. During his term, Ljubljana got its own plumbing system, gas piping, power plant, electric power railway, first public swimming pool, and Dragon Bridge.

He proposed several initiatives for development of education and pursued the establishment of a Slovenian university.

Figure 13. Ivan Hribar (1851–1941); Municipal Museum of Ljubljana.

The ingenuity of the created plumbing system enabled city growth by expanding the network and by increasing the number of wells until 1953 when a new pumping station of Hrastje had to be built in the eastern part of the city. In the water station, the same water source is used as in the Kleče water station, which made it possible for the quickly developing, mainly industrial areas of the city, to supply water from the new water station, and to increase the capacity of the Kleče water station and build essential transport piping system. The Šentvid water station was included into the supply system in 1955, the Brest water station in 1981, and the Jarški Brod water station in 1982.

As mentioned above, the first regulated discharge of water in the area of Ljubljana was in Emona. The *cloaca* – man-made channels – were placed in the west/east direction draining into the Ljubljanica.

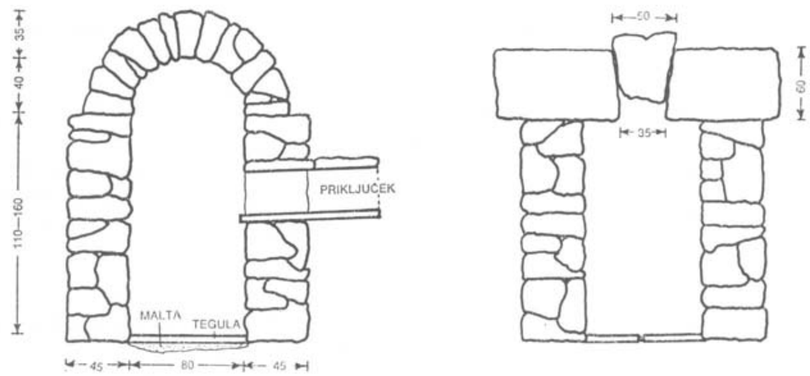

Figure 14. The Emona sewage system – channel cross sections; Source: Kolar (1983).

In the medieval Ljubljana, waste water was discharged through drenches and built channels into the river, and in shingle terrain the waste water infiltrated downwards. In May 1895, there was a major earthquake in Ljubljana, which destroyed many buildings and affected almost every building to some extent. 145 houses needed to be pulled down, amounting to 10 % of all houses in the then Ljubljana. In the following five years, international aid helped build more than 500 houses and facilitated the restoration of the same number. The city was restored according to the accepted regulation plan (today's urban plan). In 1899, it was prepared by Janez Vladimir Hrasky, later on other city architects aimed at participating in the urban planning, such as Maks Fabiani and Jožef Plečnik, respectively.

A basic element of the urban plan is – besides outlining the building areas and designing city outlook – municipal water supply management, discharge and waste water treatment. And not only waste water management, the precipitation water as well, since in sustainable management the water discharge is essential.

The Hrasky regulation planning also foresaw building of reservoirs in the left and right banks of the Ljubljanica, as well as building of a water treatment plant in Kodeljevo and alternatively in Fužine. After World War II the revised version according to Roth was realized, encompassing tow reservoirs with a discharge into the Ljubljanica behind the gate. Today, the treatment plant has not been built.

Figure 15. water sewage system dating to 1906; Source: PF (JP) VO-KA archives.

In comparison to the water piping system that was put into use in its original scope on an entrepreneur basis, the sewage system was for many years only considered as plot and road facilities and in its management there was no self-development trend identified. For a long time, the Ljubljanica served as the main discharge reservoir and its contamination/pollution was a significant put-off for the inhabitants. In the years of substantial growth, in the course of building reservoirs, an independent company Kanalizacija emerged. It was established in 1951and dealt with the development, planning, building and system maintenance. By way of illustrating the city growth, the numbers with regard to city inhabitants speak for themselves. In Emona, there were only 3,000 inhabitants, in Ljubljana in 1896 37,000, by the end of World War I 51,000, in 1940 88,000, and in 1953 as many as 138,000.

The sewage system of Ljubljana (mixed system and waste water sewage system) developed with the dynamics shown in Table 2 and Figure 9.

Table 2. Sewage system of Ljubljana.

Year	Length (km)	Channelled area (km2)	Sewage system density (km/km2)
1917	28	4,97	5,63
1945	105	10,76	9,76
1971	300	24,63	12,18
1985	593	45,61	12,99
2001	755	65,76	11,48

4. 1 CURRENT SITUATION – AN OVERVIEW

The sewage system of Ljubljana is mainly mixed (60 % of the system), however there are individual subsystems for waste water only (20 % of the system) and for precipitation water only (20 % of the network maintained by JP VO-KA Ljubljana).

The discharge and waste water treatment system is complex and needs to work without obstructions with regard to discharge and treatment and in all ratios of discharge of waste water and precipitation water, respectively. According to the conditions in the mixed sewage system, the flow at the discharge site from the main reservoir in periods of dry and wet weather, and especially during rain showers, may change to a level that makes it impossible to ensure a reliable treatment process (3.200–9.600 m3/h), therefore both reservoirs (in the right and left banks) have relief flows through which flows a diluted waste water into the Ljubljanica River. Therefore, a general solution of the sewage system that was worked out in cooperation with the Danish Hydraulic Institute in December 1996 provides for several measures (mainly regulating the overflow edge and building reservoir facilities), which are from the viewpoint of reducing environmental pollution as significant as waste water treatment plant building.

Suburbs that are at a larger distance from the reservoirs, have their own sewage systems and treatment plants. There are 14 of them: Črnuče, Dobrova, Gameljne, Horjul, Ig, Kamnik pod Krimom, Matena, Notranje gorice, Pirniče, Polhov Gradec, Smodinovec, Škofljica, Vižmarje - Brod, Zadvor.

Given are some main data related to the current state of the sewage system of Ljubljana:

Table 3. Current features of the Ljubljana sewage system.

Sewage system area	6,576 ha
Length of the sewage system (without sink hole connections):	1,011 km
– mixed channels	497 km
– waste water channels	258 km
– precipitation channels	256 km
Sewage user connections	22,603
Wells	30,662
Road sink holes	25,504
Relief system in mixed channels (into the conduits)	57
Water pumping stations (capacity of 10–320 l/s)	46
Local treatment plants	14/22,000 PE

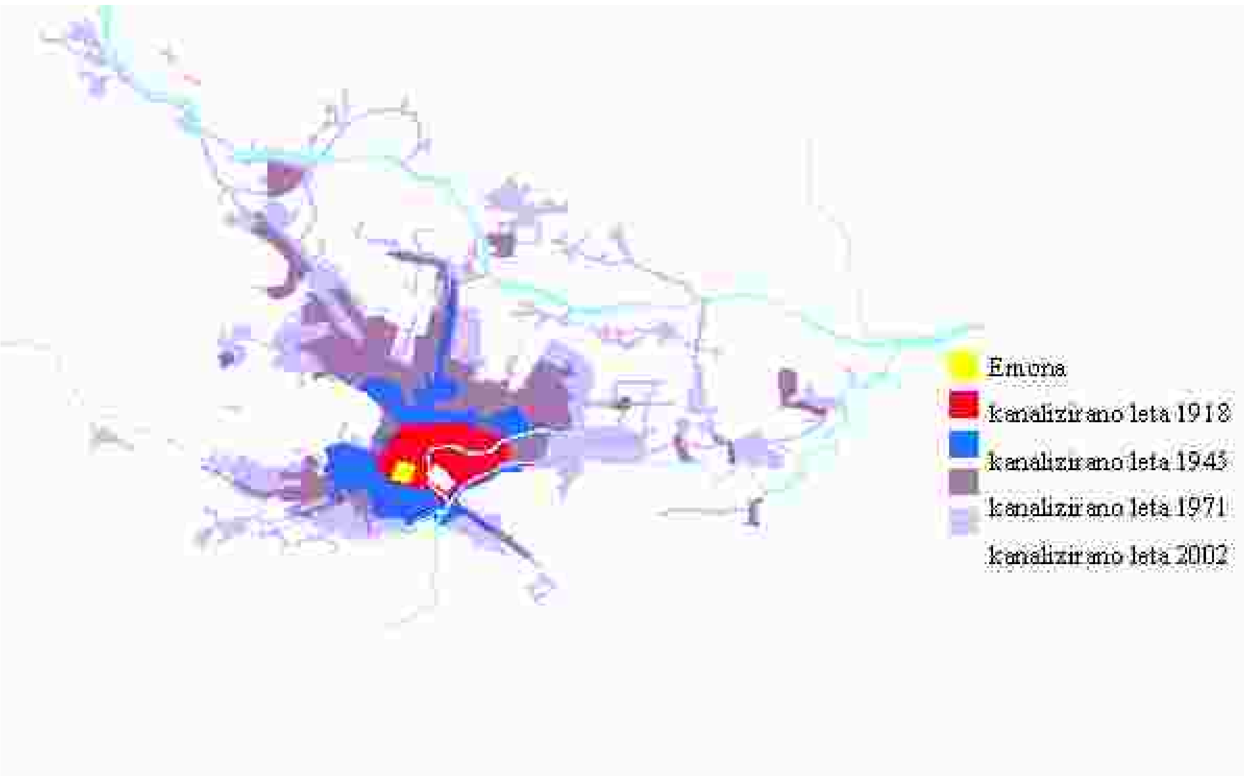

Figure 16. Historical development of the Ljubljana sewage system.

Annual volume of waste water discharged to the sites of treatment plants amounts to approx. 47.6 x 10^6 m^3, out of it 48 % of municipal waste water from households and industry. Currently, stage 2 of building of the Central Treatment Plant of Ljubljana is underway with a capacity of 360,000 PE that will enable a quality treatment of waste water and consequently a better water quality in the Ljubljanica from the class III/IV of today to class II. The final constructions of the central Treatment Plant is predicted by 2006 and will enable upgrading the sewage system of Ljubljana by connecting several peripheral areas from neighbouring municipalities (Škofljica municipality, Vodice, Medvode). The features of several parameters at the inflow area, and allowed outflow concentrations are illustrated in the table below:

Table 4. Current inflow at the CTP Ljubljana and border allowed outflow values.

parameter	inflow	border values
BPK_5	207 mg/l	< 20 mg/l
KPK	425 mg/l	< 100 mg/l
Ammonium nitrogen	31.7 mg/l	< 10 mg/l
Undissolved particles	160-291 mg/l	< 35 mg/l

The two settlements in Ljubljana, namely Rakova Jelša and Sibirija, that have developed outside the urban planning system in the south part of the city at the edge of the marshes of Ljubljansko barje will be addressed by building the local pressure depression system and local treatment plant with a capacity of 8.500 PE.

Building the missing parts of the sewage system is underway in accordance with Slovene legislation, which has been harmonized with the environmental legislation of the European Union. According to the predicted deadlines, the entire sewage system will have been built by 2017.

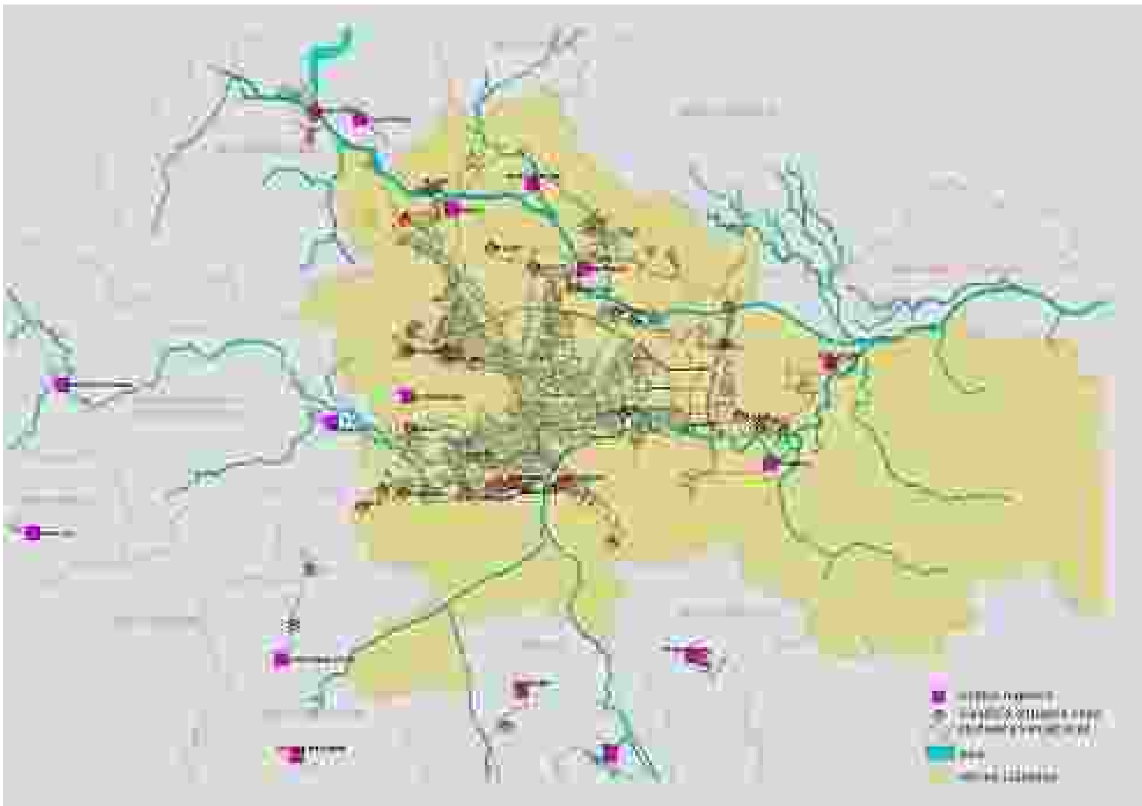

Figure 17. Ljubljana sewage system.

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