

**Restauración de Rios**  
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**Experiencias de rehabilitación y restauración de tramos urbanos**  
**(Review of the Development of Urban Rivers in Germany)**

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## **1 Introduction**

In urban areas the development of rivers is very often separated from many natural processes and subordinated to existing human utilizations. The results are channelized rivers without free space for natural development and a discharge controlled by the users. Additionally the water quality becomes increasingly worse.

While the water quality could be improved through the construction of modern sewage plants, high quality uses are often an insurmountable impediment for a structural restoration of a river. But also under the difficult circumstances in urban areas, niches could be found in which the ecological conditions can be locally improved. This short contribution will show some examples.

## **2 Characteristics of urban rivers**

Urban waters are especially designed with regard to their potential uses. In this way settlements as well as many valuable and important infrastructures can establish themselves close to the rivers. The proximity of the human uses implies that the natural development process (for example the migration of a river) must be limited. For this reason most rivers in urban areas are channelized (Figure 1).



Figure 1. Example of a channelized urban river - a rehabilitation is nearly impossible due to settlements and infrastructure

In most cases a complete restoration of urban rivers is not possible as the necessary open spaces for structural processes in the river bed are irretrievably lost for the waters. It is not astonishing that the structural quality of such rivers or parts of them is bad. A comparison of some characteristic marks of rural and urban rivers is shown in Table 1.

In the new European water framework such rivers can be classified as "heavily modified water bodies". For this type of rivers the goal "good quality" for all European rivers in 12 years could be replaced through the goal "good potential" (PATT, 2000a; PATT, 2000b).

**Table 1.** Comparison - Characteristics of rivers in rural and urban areas

Influences on ...	natural - rural rivers - influenced by ...	urban rivers - influenced by ...
<p><b>Water Cycle</b></p> <p><b>precipitation</b></p> <p><b>evaporation</b></p> <p><b>infiltration</b></p> <p><b>water storage, retention</b></p> <p><b>Discharge</b></p> <ul style="list-style-type: none"> <li>- on surface</li> <li>- subsurface</li> </ul> <p><b>flood control</b></p>	<ul style="list-style-type: none"> <li>- natural distribution; depending on the climate</li> <li>- from soil, plants and water surfaces</li> <li>- depending on type of soil, soil moisture, temperature, slope etc.</li> <li>- on the terrain surface, on the vegetation, in rivers, in depressions and lakes, in the aquifers</li> <li>- over the existing terrain surface and the river systems</li> <li>- depending on the replenishment of the groundwater aquifer</li> <li>- open space for the widening of channel cross-sections, availability of inundation areas and re-opening of floodplains often possible</li> <li>- spacious flood control concepts with flood control dikes</li> </ul>	<ul style="list-style-type: none"> <li>- ... air pollution</li> <li>- ... local building planning</li> <li>- ... local changes of temperature</li> <li>- ... artificial surfaces</li> <li>- ... reduced due to the sealing of surfaces</li> <li>- ... artificial basins (for example flood-control reservoirs, reservoirs in the sewage systems)</li> <li>- ... discharge over artificial surfaces, for example roofs, gully and sewage systems (combined and separate sewer systems)</li> <li>- ... the reduced infiltration rate, i.e. reduced regeneration of groundwater aquifers</li> <li>- ... technical constructions (dykes, flood control walls, mobile walls)</li> <li>- ... flood forecast necessary</li> <li>- ... flood control measures necessary due to the flood damage potential in the endangered areas (infrastructure, settlements)</li> <li>- flood control management</li> </ul>
<p><b>Water body</b></p> <ul style="list-style-type: none"> <li>- river bed</li> <li>- riparian areas, river banks</li> <li>- riparian vegetation</li> <li>- free passage of organisms in longitudinal direction (in and against flow direction)</li> </ul>	<ul style="list-style-type: none"> <li>- open river bed; bed load transport possible</li> <li>- natural bank slopes</li> <li>- riparian areas with a typical regional vegetation of the region; often</li> <li>- sometimes reduced because of transverse buildings (weirs), but can be often improved by artificial migration constructions (fishways, bypasses etc.)</li> </ul>	<ul style="list-style-type: none"> <li>- ... channalization, smooth river bed; missing interstitial</li> <li>- ... channalization; vertical banks and uniform bed contours</li> <li>- ... human uses up to the river banks; therefore less or no area for riparian areas available</li> <li>- ... without or atypical riparian vegetation; riparian areas influenced by human uses</li> <li>- ... infrastructure, settlements close to the river and transverse building in the river</li> </ul>
<p><b>Water quality</b></p> <ul style="list-style-type: none"> <li>- effluents</li> </ul>	<ul style="list-style-type: none"> <li>- mainly indirect discharges</li> <li>- important influence of existing agricultural uses</li> </ul>	<ul style="list-style-type: none"> <li>- ... direct and indirect discharges, intermittent impacts through reservoir outflows</li> </ul>
<p><b>River maintenance</b></p>	<ul style="list-style-type: none"> <li>- regular maintenance often not necessary</li> <li>- ecological river maintenance possible</li> </ul>	<ul style="list-style-type: none"> <li>- ... through cleaning of river bed</li> <li>- ... avoidance of danger; important reason for river maintenance</li> <li>- ... greater public participation</li> </ul>

### **3 Impacts on design - population, town and river**

With increasing environment consciousness of the population and the realignment of the legal bases in the federal water law (Wasserhaushaltsgesetz - WHG) the design criteria for urban rivers have changed. Today typical requirements on the management of urban rivers are:

- Flood control (PATT, 2001; PATT, 2000c)
  - Constructional precautions
  - Organisational and behavioural precautions
  - Flood control management
- Restoration of natural run off
  - Support infiltration (for example, permeable surfaces for yards, parking areas, footpaths and residential streets)
  - Water retention in hollows and ditches
  - Rain storage reservoirs
- Consideration of town planning and protection of monuments
  - Re-establishment of functional and design references between water body and town
  - Areas for local recreation
  - Consideration of specific ecological components in town planning
  - Protection and maintenance of cultural assets
- Natural development and maintenance of rivers (PATT, JÜRGING & KRAUS, 1998)
  - Restoration of free passage for water organisms and bed load material
  - Re-opening of closed water reaches
  - Toleration of a minimum flow dynamic with changes of the morphological bed structures (support of natural river development)
  - Development of riparian areas
  - Considering of nature protection specific and ecological interests in river maintenance (for example breeding-time of birds, spawning times)
- Leisure and recreation on rivers
  - General suitability of a location and infrastructure for special forms of recreation
  - Control and regulation of activities
- Aspect of public acceptance
  - Improvement of information policy
  - Comprehensibility of all planning decisions

In a well balanced river development planning process all aspects mentioned above must be taken into consideration. In the new European Water Framework Directive (WFD) from July 4<sup>th</sup>, 2000, these and other aspects will be managed and controlled with the help of river management plans (EUROPEAN UNION, 2000).

### **4 Reference to the design of urban rivers**

The proximity of uses and their concentration are the most important difference between river development planning in urban areas and those in rural areas. Since in urban areas, a larger number of actual or possible influences must be taken into consideration, those plans are usually more extensive than those in rural areas.

Table 2 shows some parameters that may be significant in the particular case of urban rivers. This list is certainly not complete due to the many influences that may occur in urban areas.

### **5 Examples**

River developments in urban areas are very often limited due to existing uses. The restoration planning and the possible design of the rivers has concentrate on a few types of restoration. Typical measurements are, for example:

- Natural development of some particular reaches of channelized river
- Natural development of a small river
- Re-opening of tubed river reaches
- Restoration of free passage in longitudinal direction
- Design of bridges and culverts

For instance, two types of restoration will be presented.

**Table 2** Parameter influencing river development planning (without claim for completeness - here especially for urban rivers)

Datas for planning	Thess parameters may in particularly important ...
in general	<ul style="list-style-type: none"> <li>- Development planning (urban building plans and land-use planning), planning and building permissions, property market, land prices</li> <li>- River development planning (“Leitbilder”, development objective, development)</li> <li>- Questions of ownership, demand for land of the communities, existing water rights</li> <li>- Commitments with regard to water laws</li> <li>- Marginal economic conditions               <ul style="list-style-type: none"> <li>- financing, results of cost-benefit-analysis</li> <li>- maintenance costs</li> <li>- grants by state governments</li> </ul> </li> <li>- Course of construction, aspects of construction programme</li> </ul>
concerning the river and river meadow, riparian areas	Discharges resp. water levels <ul style="list-style-type: none"> <li>- Main hydrologic data               <ul style="list-style-type: none"> <li>- Low flow resp. flood discharges- (discharge and annuality of events)</li> <li>- Stagnant waters (lakes, storages, aquaculture etc.)</li> <li>- Extension and form of the catchment area</li> <li>- Size of the water (brook, river, stream)</li> </ul> </li> </ul> Design flood, design water level, channel, river bed <ul style="list-style-type: none"> <li>- <u>Natural</u> channel form (channel pattern, <u>cross-sectional</u> forms, <u>longitudinal</u> profile <u>and</u> river <u>bed</u> structures)</li> <li>- Inundated areas, danger of flooding, possible flood damage</li> </ul> Water quality <ul style="list-style-type: none"> <li>- Maps of water quality</li> <li>- Effluents (aspects of quality and quantity; direct and indirect dischargers)</li> </ul> Structural quality of rivers <ul style="list-style-type: none"> <li>- Maps of structural quality of rivers and adjacent riparian areas</li> </ul> Ecological improvement and aspects of nature protection <ul style="list-style-type: none"> <li>- Areas for nature protection and preservation of species</li> <li>- Compatibility with the goals of nature protection</li> <li>- Development potential in existing areas</li> </ul> Utilizations in and on water bodies, river meadows, river valley <ul style="list-style-type: none"> <li>- Kind of building resp. uses (settlement, infrastructure, industry, agriculture, hydropower, water supply, fisheries, leisure and recreation)</li> </ul> Flood control (PATT, 2000c; PATT, 2001) <ul style="list-style-type: none"> <li>- Flood warning and flood forecast, flood risks</li> <li>- Flood control structures</li> <li>- Flood damage potential</li> </ul> Hydraulic structures, hydraulic installations <ul style="list-style-type: none"> <li>- Control buildings, embankments, weirs, dykes, hydropower installations</li> <li>- Outlets, diversions, water removals, water disposal systems</li> <li>- Withdrawal and addition of water</li> <li>- Leisure and recreation facilities</li> </ul>
concerning the specific situations in an urban area (urban catchment)	Aspects of sanitary engineering <ul style="list-style-type: none"> <li>- Percentage of sealing, kind of pavements</li> <li>- Urban canalization (separate or combined systems, water storage in the channalization, hydraulic structures, control and steering mechanismen)</li> <li>- Pumping facilities</li> <li>- Waste water sewage plants</li> </ul>
concerning groundwater	<ul style="list-style-type: none"> <li>- Geohydrologic aspects, groundwater recharge, groundwater sampling</li> <li>- Rate of subsurface water flow, artificial replenishment of groundwater, groundwater pollution</li> <li>- Groundwater uses</li> </ul>



### 5.1 Restoration of a short river reach

For natural development a river needs free space that is very often not available in urban areas. If there are no open spaces a structural improvement can be attained by forming a natural river bottom, raising berms and bringing in typical plants (Figure 2). For leisure and recreation the access to the water body may be important (PATT, 1997; PATT, 2000d). A possible reduction of channel efficiency must be taken into consideration.



Figure 2. Natural development of an urban river through forming a natural river bottom and typical vegetational cover

### 5.2 Re-opening of channelized river reach

In the past many rivers in urban areas were tubed and sometimes completely disappeared from the field of vision. The areas on the surface that were won through tubing are today very often traffic areas or through other utilizations at least in parts irretrievably lost for the rivers. However there are water reaches that may be re-opened through relinquishment, resettlement or displacement of utilizations (Figure 3).



Figure 3. Tubed reach of a small river - the water is located under the flagstones

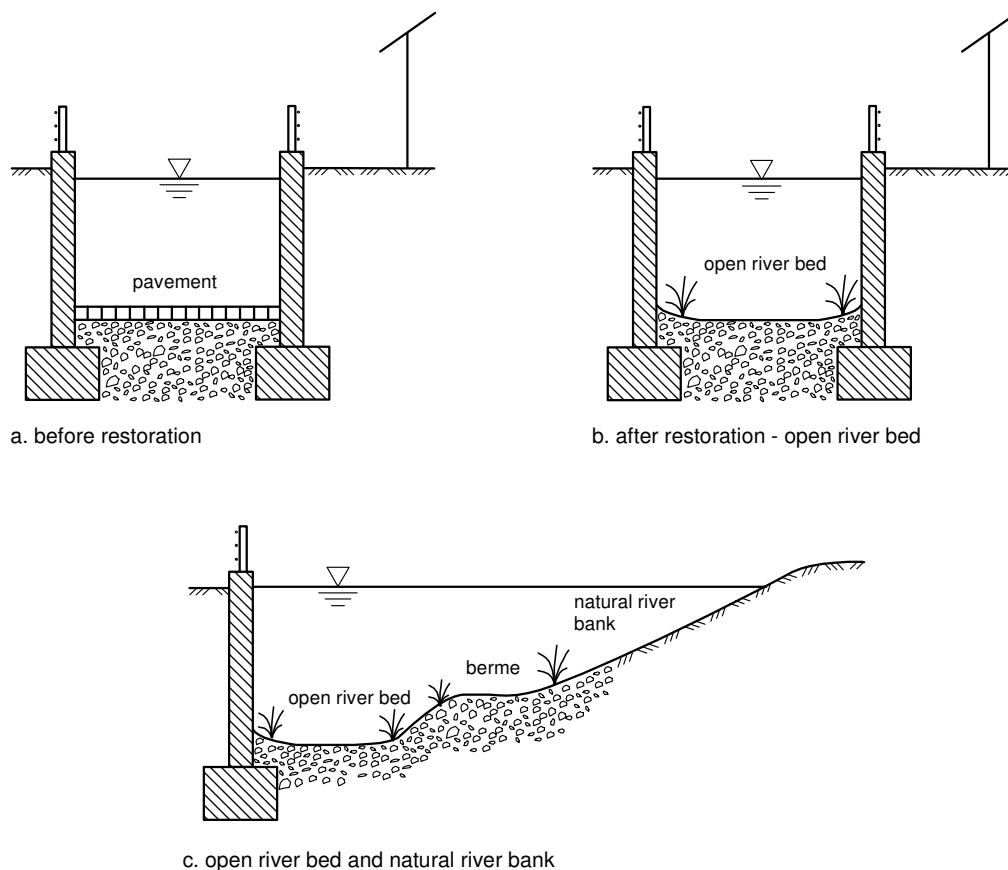


Figure 4. Possible designs of a river reach after re-opening

Each opening of a tubed river reaches means a recovery of typical river habitats. Step by step such small measures can be a considerable contribution for the rehabilitation of urban areas. The effects on the channel efficiency must be clarified to avoid flood damages. It is also important to organize the maintenance of the re-opened river.

## 6 View

The natural development of rivers in urban areas are influenced by human utilization. In spite of many restrictions, niches for an ecological improvement may be found. Ecologic improvement must not to be faced as embellishments. For the realization of project, the combination of nature protection, creating areas for leisure and recreation and revaluation of urban areas can be of considerable importance. It is the concern of the river development planning to coordinate all the different aspects that influence the planning process.

## 7 Literature

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