The Isar Experience –
Urban River Restoration in Munich

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Abstract
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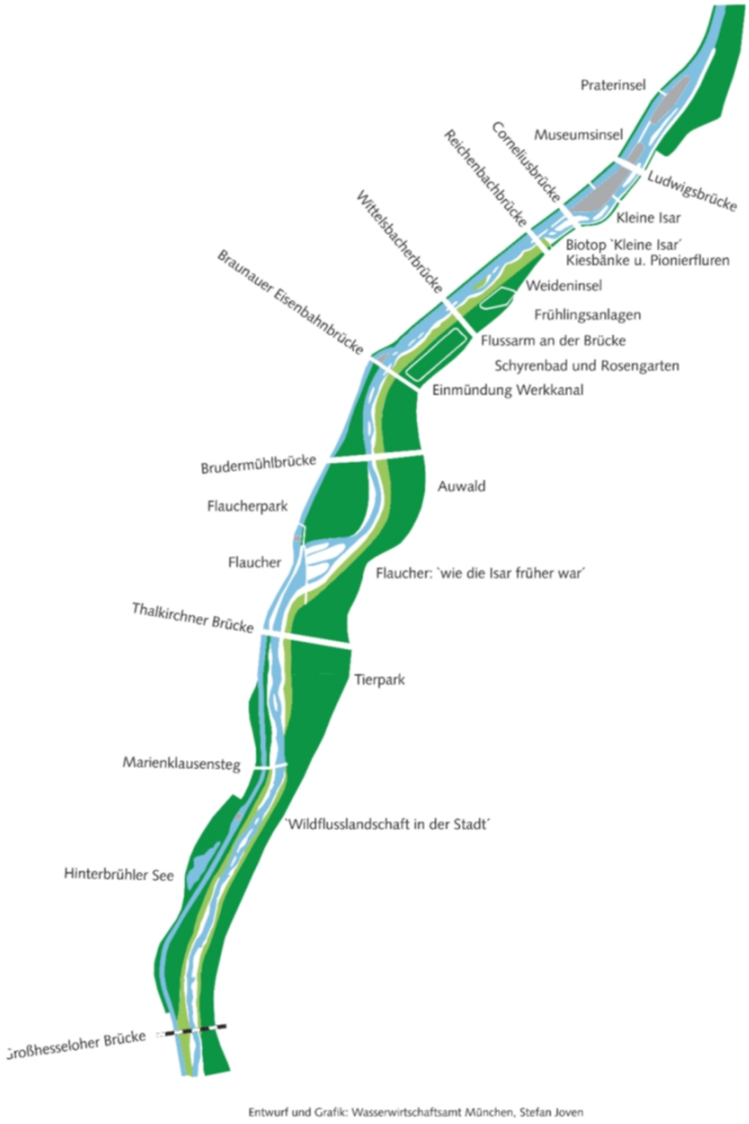
An urban river restoration project has been in progress on the River Isar since the beginning of the year 2000. Within the scope of the "Isar Plan" local flood protection is improved and ecologically valuable habitats for fauna and flora are restored. At the same time, the growing demand of city dwellers for natural landscapes in central urban areas for leisure and recreational use is met in an ideal manner. In all, the joint project of the State of Bavaria and the City of Munich is more than just the restoration of a stretch of the River Isar extending over 8 kilometers in the Munich area, it is also an investment in the future. This urban river concept combines the nature-oriented redesign of a river with an urban lifestyle, it goes well beyond simple cost-benefit analyses and is of immeasurable value for the population.

The Isar in Munich – an urban river landscape adapts to the winds of change

Ideas on an integrated urban river development concept for the River Isar started in Munich back in the nineteen eighties. At that time, the issue was to improve the water quality due to increased pressures from sewage plants and stormwater overflow, whereas today the "Isar Plan" focuses on an improvement in flood protection, the development of a river landscape close-to-nature as well as on leisure and recreation activities. The project was launched in 1995 by the Bavarian Water Management Agency in Munich and the City of Munich. Under the slogan "New Life for the River Isar" work has been in progress along the Munich stretch of the river since the beginning of the year 2000. The State of Bavaria and the City of Munich are spending some 28 million euro on this River Isar renaturation project that extends 8 kilometers from the southern city border, at the Großhesseloher Bridge, to the inner city at the Deutsche Museum (Museuminsel). (Fig. 1).

Meanwhile, a stretch covering approximately 7 of the 8 kilometers has been recovered as a near-natural landscape. Different river sections have since emerged that have been designed to match their urban environment, each of which has developed its own charm and own dynamic development. The challenging remodeling of the inner-city stretch has yet to be tackled and is planned to take place over the next three years.

Fig. 1: Map of the “Isar Plan” project



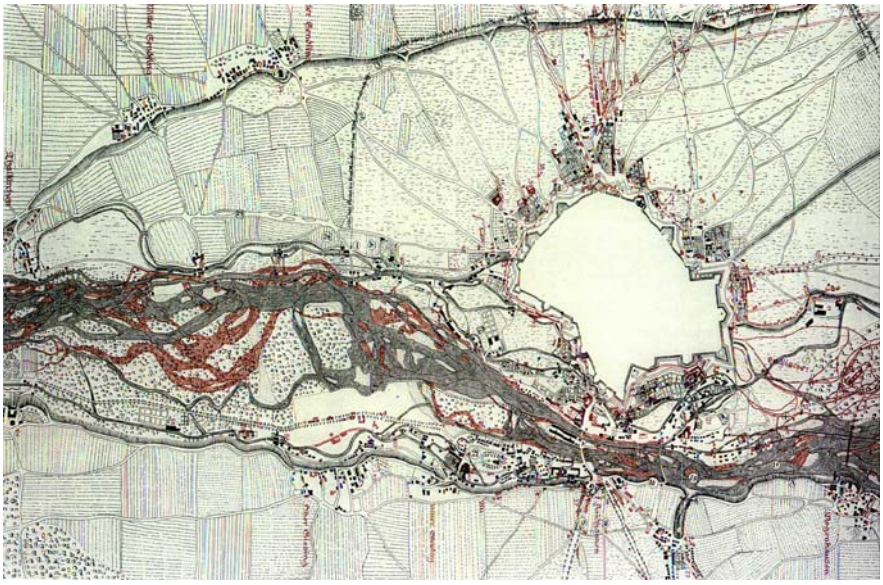
Before hydraulic regulation began in the middle of the 19th century, the pre-alpine River Isar flowed in the Munich area in a constantly changing river bed with extensive gravel banks and river branches. The quickly rising floodwater that brought large quantities of debris and gravel from the Alps, regularly changed the river landscape. Areas of Munich situated at lower elevations were regularly flooded (Fig. 2).

The systematic development of the river bed as well as the utilization of hydropower in the power canal alongside the River Isar in 1920, embedded the Isar in a fixed, linear channel of approx. 50 meters in width with trapezoidal cross-section, comprising the main channel, forelands, flood meadows and flanking flood embankments.

As a result of the canal-like development and also through removal of the bedload in the upper course, caused by the Sylvenstein reservoir that went into operation in

1959, the River Isar has slowly but surely lost its natural torrential river character for ever. The gradual degradation of the river bed was counteracted by regular placement of low weirs or cross-river sills in the longitudinal course. Reduced flow, unvaried flow conditions and uniform river structures had a detrimental impact on flora and fauna and also on the landscape scenery. Only at the “Flaucher” - which is a part of the Isar floodplains near the inner city that has practically maintained its natural character - can one sense the original flow of the ramified River Isar with its open gravel banks and alternating gravel stone islands. This area therefore also has a model function for the near-natural restoration of the River Isar.

Fig. 2: Historic river course of the Isar in Munich in 1724 (black) and 1808 (grey)



The Isarauen flood meadows are extremely popular as a natural landscape and as recreation space and are one of Munich’s most diversified sites for recreation activities. There is no other urban open space that is used so naturally and in such a relaxed manner as here along the “Süd-Isar” in the south of Munich. Thanks to the Isar Plan the “wild river landscape” has now returned to the city and is experienced by the urban population as a near-natural flowing body of water.

More space and new banks for the river

In the first construction sections, in the south, between the Grosshesseloher weir and the Flaucher footbridge, the Isar has undergone substantial change: through the widening of the main channel, incorporating the forelands along the river and the floodplains, the flood runoff has been improved and space created for development and design measures in the river and on the river banks. The steep embankments secured with concrete slabs and paving have been replaced with flat sloping banks and naturally developing banks. A fixed, canal-like river bed has become a river bed of varying width with gravel banks and gravel stone islands which develop dynamically in a system of coming and going. (Fig. 3)

Technically designed cross-river sills with linear cross-section that are spaced at 200 meters with drops of max. one meter cannot be passed by fish in most cases. These have been replaced by flat ramps with stone rock steps in a honeycomb design with

intermediate pools. These measures not only restore a near-natural appearance of the River Isar, but also improve the living conditions and types of habitat for flora and fauna characteristic of the River Isar.

The special design of the rough ramps are a key design element for an enhanced natural development of the river regime. With their pools, stone rock steps and the downstream gravel banks and gravel stone islands they not only have an important ecological function for aquatic habitats, but also contribute towards the overall morphological development of the river bed. And the natural look of these man-made structures also provides an attractive site for recreation.

Fig. 3: Broadening of the main channel bed

After removal of the cross-river sills that are fixed under water by sheet pile walls, a 25 cm thick filter layer (particle size distribution U = 2) with a particle diameter d_{50} = 40 is installed. The fill of the ramp body is implemented with a 1 : 15 to 1 : 25 gradient and is made of armor stone with a diameter d = 20 to 50 cm. The course thickness is 60 cm. The superstructure comprises stone blocks with edge lengths of between 0.9 and 1.3 meters that are placed in the fill of the ramp body in the flowing water body, without intermediate spaces.

The honeycomb structure is the result of longitudinal and horizontal stone blocks that support each other. The structure of the ramps is of an inhomogeneous design, the blocks are not staggered at an even height or with a uniform spacing. As a result of the varying steepness of the areas within the ramp and raised step sections, the flow and the formation of gravel stone banks and islands in the downstream water can be influenced up to the mean discharge (Fig. 4).

The loosely arranged ramps have a canoe route a well as a “Talweg” within the ramp structure, which enable those fish to ascend that are unable to jump obstacles. The biological continuity for fish and macroinvertebrates will now gradually be restored through the converted rough ramps. Individual fish passes in the form of bypass streams – such as those that exist at the “Flaucher” floodplains take care of the rest.

Leaving deadwood of tree trunks and rootstocks embedded in the banks and the river bed as well as driftwood encourage the development of small spaces in the river structure and serve as a refuge for young fish and as maturing ground for water organisms. In addition to the macroinvertebrates (Makrozoobenthos) in the River Isar, which have an important ecological function for the river as well as being a source of food for fish, the situation for animal species that dwell in the land-water transition area is also being improved, e.g. little ringed plover (Charadrius dubius) that nests in the gravel banks, or the white throated dipper. Gravel sites are places where pioneer plants germinate, the seeds of which have been washed down from the Alps by the Isar, ground beetle species that have adapted to the site are also settling.

Fig. 4: Top view of a rough ramp in loose flat stone block design (schematic view)

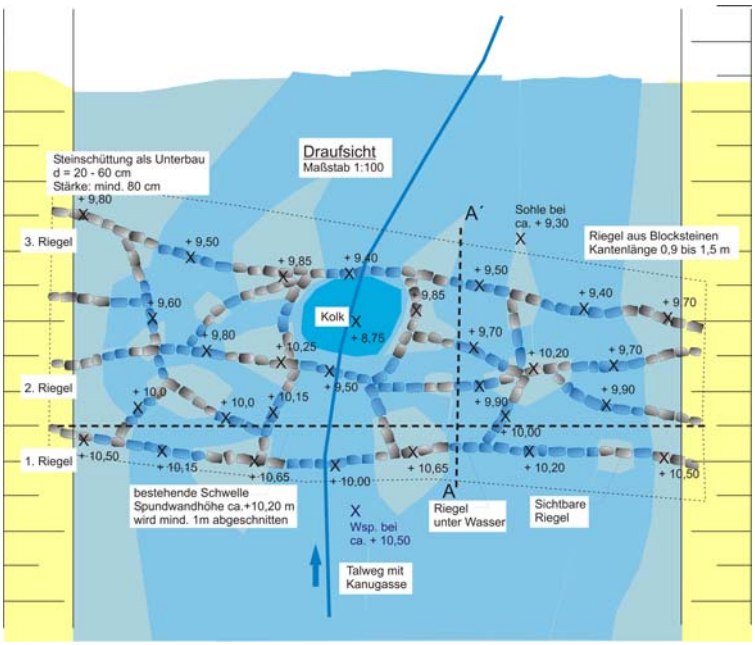
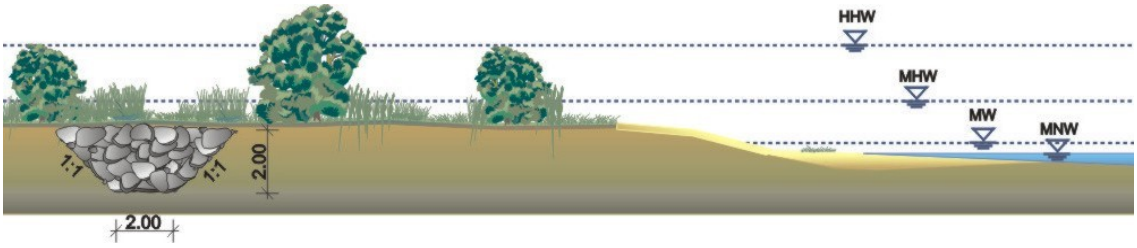


Fig. 5: Rear-defense river bank protection (schematic)



The dynamically developing banks are a special feature and are constantly changing and retreating during high water levels and flood runoff. To arrest erosion rear-defense protection measures were implemented in the forelands for safety reasons. These developing banks were provided mostly in the pilot stretch of the Isar Plan, to the south of the Marienklausensteg footbridge, where the foreland, upstream of the dyke, offers sufficient space for a controlled river development (Fig. 5).

The ditches measuring 1.5 to 2 meters in width and depth were filled with material that originated from the removal of the built bank structures. At high water levels the river can advance up to this reinforced line through erosion, without causing any damage. In this way the riverbed broadens on its own accord. An attractive and unrestrained riverbank development gradually takes over with ecologically valuable steep banks and flat gravel slip-off slope banks. (Fig. 6).

In the inner city the Isar Plan has to deal with several restrictions in the river development, due to the existing infrastructure. Besides bridges there was also a stormwater discharge, a mobile weir system for the emergency water supply of a cogeneration power station and pipe junctions from different utilities that had to be incorporated in the plans for implementation of the measures. At these sites there is no alternative but to use classic waterway construction measures with paving and built structures (Fig. 7).

Nevertheless, widening of this section of the river will also be implemented wherever possible. Some of the waterside meadows will be terraced and designed in such a way that the substantial difference in the elevation of the foreland and the River Isar will level out on its own accord making access to the water more convenient. And the visitor will be able to enjoy a varied scenery with gravel stone areas, meadows and islands in the River Isar. Beyond this, the linear cross-river structures are converted into river bottom ramps of a loose stone rock design (Fig. 8).

Fig. 6: Dynamic bank development with vertically dropping bank washouts (rootstock)

The area of the recovered section stands out distinctly where it intersects with the next and final river section that is still designed like a canal and awaiting development. Very different to the more freely developing sections in the south, here in this inner city area there is a much greater difference in the river

and floodplain elevations and the distinct character is the strong contrast between the closeness to buildings on the one hand and the experience of a close-to nature urban river landscape on the other hand.

Flood control: more essential today than ever before

To the west and to the east of the River Isar, in the southern part of the city, the river is accompanied by an extensive flood embankment system that originated in the nineteen twenties. Based on hydraulic calculations freeboard deficiencies of up to one meter were determined. The old dykes were also partially in need of remediation. The design flood HQ_3 with a runoff of 1,100 m^3/s at gauge Munich is used to determine the design of the flood dykes. At this discharge the freeboard must be at least 1.0 meter. This also takes into account the availability of a flood water retention area of over 53 million cubic meters in the Sylvenstein reservoir, 80 river kilometers upstream. Thus, during the floods of 1999 and 2005 the runoff in Munich - which without the flood reservoir would have reached over 1 500 m^3/s or 1 800 m^3/s and would have been devastating for the city - was kept at levels of under 860 m^3/s and 1,050 m^3/s respectively.

With regard to the regional impact the Sylvenstein flood reservoir has on the Bavarian Oberland (area to the south of Munich extending to the Alps), the flood events of recent years have shown that the implemented measures were an essential part of a comprehensive flood control concept.

Based on the importance of the Isar river basin for recreation purposes and its protection status as landscape conservation area or FFH area, flood defense measures were chosen that mostly maintained the existing undergrowth on the dykes. A sufficient runoff capacity was not achieved by building new dykes or substantially increasing the height of the existing dykes, but rather by broadening the main channel bed which simultaneously enables near-natural and flat river bank stabilization.

The old dykes with their significant tree population in the stretch between the Thalkirner Bridge and the Marienklausensteg footbridge, as well as between the Flaucher region and the Wittelsbacher Bridge required particular stabilization. To this end, the dykes were reinforced with a diaphragm wall over a length of several hundred meters using the mixed-in-place method, which, in event of a disaster with waterside damage to the dyke embankment, secures the stability of the dyke. This intricate measure makes it possible to substantially maintain the existing trees on the dykes and thus also the typical scenery (Fig. 9).

In areas with reduced dyke safety, new dykes were filled in front of the old ones in order to maintain the air-side tree population. The water-side sealed embankment with its thin layer of top soil is an ideal site for species of dry grassland.

By sowing indigenous wild herbs and spreading cut hay that originates from glacial relicts, among other species, taken from the nature conservation area “Garchinger Heide”, on the new dyke embankments and in the foreland, the scars left by the construction work in the first development sections quickly healed. In the meantime, flowering dykes of the River Isar give the impression that they developed a very long time ago.

Learning by doing – the fold of 2005

The big flood of 2005 generally had a major impact. “Embedded” gravel stone islands were eroded or moved, cross-river sills already graveled up were partially exposed again.

To begin with, in the renaturated main channel bed with its protruding and receding stabilized banks, a number of gravel stone banks and gravel stone islands formed after smaller and average flooding.

Fig. 7and 8: Channel-like development of the Isar river bed in the urban area (“before”) and near natural development in the urban area (“after”)

Fig. 9: Placement of diaphragm wall in old dykes using mixed-in-place method

However, the big flood caused a washout of areas behind the bank stabilization along some sections of the protruding banks, and in the area where the stone block ramps integrate with the bank. Erosion damage occurred especially along beaten paths on the top edge of the embankment where there is no protective turf or where such had not yet developed.

Many of the new structures that have developed such as pools, dips and gravel banks are more or less directly associated with the level of the River Isar, depending on the discharge, and are permanently covered with water or frequently wetted. At the same time, the biotope character of these areas is enhanced by allowing deadwood to remain after flooding. Thanks to the successful stabilization of the dykes these small biotopes can be maintained. On the surfaces exposed by flooding, thin but richly flowering grass communities of high ecological value developed in the following year, also because these areas are seldom walked over due to their rough surface structure.

“Real” flood damage caused by a washout of the bank protection, that had to be repaired immediately, occurred over a stretch of approx. 350 meters to the south of the Brudermühl bridge. The undercut slope bank with its stabilization of stone blocks having an edge length of 1.3 meters, and assembled in terrace form, are extremely popular. However, because of the steep structure in connection with a wide beaten path immediately behind the top row of stones, there was substantial backwashing behind the stabilizing structure which led to its collapse.

The best protection was to be found where the technical bank protection measures were supplemented by the planting willows or turf. Especially the thin willow rods that develop after cutting back every two to three years provide an exceptionally good hold.

An impression of the described river dynamics can be gathered from the new development of still areas and pools in the foreland, which are a result of the summer floods of 2005 and which are connected to the river. These provide an ideal habitat for young fish and macroinvertebrates. The damaged sites caused by the floods were maintained as far as possible. Planting measures and willow cuttings restrict access to these sensitive areas and prevent a further washout.

The urban section – trying to find the best solution

The course of the River Isar through the city of Munich, with it floodplains, arch bridges, weirs as well as the old trees and parks, forms one of the most distinct and popular urban areas in Munich. Based on its closeness and easy access it is used intensively for strolling along, cycling, sunbathing and relaxing.

Outlook

The Isar Plan has been a successful inner-city river landscape project. Although the results can already be identified today, the really positive impact of the urban river concept will not be revealed until completion of the project in 2010. The potential has yet to be fully exploited. In the long term the foundation for a close-to-nature urban river design has been established which excellently combines flood protection and urban recreation requirements.

The vision of the River Isar in the 21st century is not the original pre-alpine river landscape, but rather a river that reflects is alpine origin. A nature-oriented river landscape in the city that presents the metropolitan population a nature that is intact and attractive scenery for the nature lover, on the one hand, and, on the other hand also provides a habitat for indigenous river plants and animals. The exemplary renaturation measures of the River Isar project demonstrate what an urban river development that is close to nature can achieve.

The impact of the project has already spread well beyond the borders of Munich. This was also helped by the first DWA 2007 river basin management award going to the “Isar-Plan”. The project partners of the State of Bavaria and the City of Munich express their thanks for this acknowledgment.