CASE STUDIES: ISAR; GERMANY

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ABSTRACT: Like most of the larger rivers in middle Europe sections of the Isar, flowing from the Alps down to the Danube, were canalised more than hundred years ago, to improve flood control and the use of hydropower. The floods in the last two decades showed the needs to improve flood protection and accelerated the discussions about more nature and outdoor recreation along the rivers. The basic for restoration projects are regional river concepts. They contain the guidelines for local restoration project and also for the measurements program as part of the management plan, asked by the EU-Water Framework Directive. A restoration project requires teamwork, needs ecological understanding, technical knowledge in hydraulics /construction and social acceptance. Engineers, architects and experts of different fields (e.g. ecology, urban planning, nature conservation, wildlife, agriculture, forestry and fishery) are working together to find win-win-solutions. Such projects have to be supported by the public e.g. engaged Non Governmental Organisations (NGO's). The case study Isar includes projects in the city of Munich (8 km) and outside in the rural floodplains (100 km); it describes planning steps, the restoration measurements to improve flood control, ecology and outdoor recreation and the main objective: bringing back the alpine character of the Isar by allowing again the hydro morphological processes.

Keywords: river restoration, flood control, ecology, biodiversity, outdoor recreation, hydro morphological processes.

1 INFORMATION ABOUT THE ISAR

There are several restoration projects along the Isar. They include projects in urban areas, like the Isarplan Munich, and restoration projects north and south of Munich in rural zones. Before these projects will be described, some numbers about the Isar are given:

The Isar

The Isar runs from the Karwendel Alps to the Danube. It watershed covers about 9000 km^2 with about 2.5 million of habitants, more than 1.5 million in the city of Munich. The length of the river is more than 260 km. The annual precipitation in the mountain areas is more than 2000 mm/a, close to the Danube less than 700 mm/a. Floods occur mainly from spring to fall. The discharges in Munich are:

NMQ (low flow)	30 m^3/s
MQ (medium flow)	90 m^3/s
HQ (high flow)	350 m^3/s
HQ (Spring 1999)	870 m^3/s
HHQ (maximum flow)	1440 m^3/s

Fig. 1 Watershed of the Isar

Up to the beginning of the 19th century the Isar was a free flowing braided river system from the Alps down to the Danube. During low flow the water gets nearly lost between a corridor of gravel banks within a belt of alluvial woodland. Wetland with oxbows and groundwater streams accompanied the river system. The dynamics processes of erosion and sedimentation provided habitats for alpine plants and special animals. The succession of the vegetation were controlled by floods, transport and relocation of gravel and sediments.

Fig. 2: A natural section of the Isar near the Alps, reference status for restoration projects – gravel banks within the river, which will be relocated with each flood.

River canalisation

On the beginning of the 19th century river construction started. The objective was to get the river in a fixed bed, to improve rafting and land use and to reduce flooding. The first construction works were done in the cities of Munich and Landshut. About 100 years later, at the beginning of the 20th century, the canalisation of the Isar from Munich down to the Danube was completed, dikes were been built to protect urban and rural land from flooding. Between 1954 and 1959 the Sylvenstein Dam at the edge of the Alps was built as a flood reservoir, controlling the floods in the Isar valley down to Landshut.

Hydropower

Already in the middle age water was used to run mills. Along the Isar only large communities like the cities of Munich and Landshut were able to build and to maintain weirs, which were endangered by each large flood. Water was taken at these weirs in channels to run mills. The technical development at the beginning of the 20th century allowed using hydropower to get electricity. This was the start to built weirs and channels at the upper part of the Isar, between the Alps and Landshut of more than 150 km of the River length, to withdraw the water from the river bed into channels to transport it to Hydropower plants. The riverbed itself remains for the most time of the year mostly dry, only to carry the water during floods. With the renewing of the concessions for this river sections in the last 10 years, the minimum discharge in the river bed was raised from 5$m^{3/}$ to 15 m^3/s restoration projects were started, up to 75 % financed by the hydropower companies.

Fig: 3 Diagram of water extraction for hydropower along the Isar between the Alps and Landshut

Natura 2000
Besides the alternation of the Isar from a free flowing river and the loss of habitats, there are today many protected natural areas, especially from the Alps down to Landshut. In this section a wide corridor of woodland follows the river, only disrupted by the cities of Bad Tölz and Munich. The Isar, as an alpine river, offers a corridor of habitats for alpine animals and plants migrating from the Alps down to the Danube. For this reason more than 100 km of the Isar, flowing in Bavaria are reported for Natura 2000, covering habitats with rare specious of animals and plants, protected at European level.

2 CASE STUDIES

2.1 Isarplan, City of Munich
In Munich the Isar is getting restored for a length of 8 km. The City of Munich and the Regional Office for Water Management put up the ISARPLAN to improve flood control, ecological functions and recreation. For this a planning group was installed with water engineers, landscape architects, city planners and biologist working together. The planning steps included meeting with Citizen-groups and members of all kind of NGO, like nature conservation -, fisher-and kayak-groups, they all were represented by the Isar-Alliance. The planning stage of the restoration project was implemented 1995, in fall 2000 the work started, till today 6 km of the project are restored. The last sector of about 2 km was approved by the city council in spring 2005 and will be finished 2010. The project will cost about 28 Mio. Euro, 55 % is paid by the State of Bavaria, a part of it is sponsored by the European Commission and 45 % covers the city of Munich.

Starting position
The Isar in Munich got canalized about 1900 in a double trapeze profile, with the river bed and a floodplain. The floodplain is limited by walls and dikes. There were no gravel banks. The steep banks got protected with heavy stonework and concrete. To step down to the water was for kids and oldies quite dangerous, they needed to be sporty to get to the water. Small weirs had to prevent the incising in the river bed; they interrupted the longitudinal connectivity for boats and fishes. The flood corridor was grassland, regularly mowed and maintained as green grounds for soccer and other sports. Due to the discharge for floods, there were only a limited amount of trees and shrubs.

The water is taken into a channel, more than 6 km of the 8 km restoration section has only a minimum flow of 5 m^3/s, but has to take the floods and 2 km has the natural flow. At the moment there are discussions with the hydropower company to raise the minimum flow up to $15m^3/s$.

Fig. 4: The Isar in the city of Munich, south of Deutsches Museum. The canalized Isar with its flood corridor and meadows (built about 1900)

Planning approach and Public participation
In urban areas, where available space is limited, river restoration projects are mostly restricted. In Munich the flood corridor, offering some space, could be integrated in the restoration project. From the start of the Isarplan 1995 the public was asked to accompany the planning process. People got interviewed about the new river and what they would prefer. There answers were different: The younger people were asking for more gravel banks and an open, easy access to the water, the older wanted more grassland. The compromise was to widen the river for 30 % to bring back the gravel bank, but keep about 60 % of the existing meadows for playground (e.g. Soccer) and for the dogs. The results of these interviews were the guideline for the planning process and include:
- to ensure flood control,
- to bring back the alpine character of the Isar into the city,
- to enlarge the gravel banks along the river, especially wanted by the youngest
- to keep the flood meadows wanted by the oldies (dogs like grassland),
- to keep the tress and the nature vegetation,

• to improve recreation like sun bathing and bathing in the river and
• to readmit the ecological functions, e.g. longitudinal connectivity.

Planning competition
For the last restoration section in the city, south of the Deutsche Museum, architects and engineers were invited into a competition to find an acceptable solution. The winner recommended a more technical solution, but this was resisted by the Citizens of the surrounding quarters. After a mediation process the solution now is found, which follows the more natural restoration principles, which were chosen for the sections, already finished.

Flood protection measurement
The main objective of the Isarplan is to improve flood protection for a hundred year flood. To achieve this, the river canal has to be widened. The bank and the adjacent flood corridor were lowered to enlarge the hydraulic section for the discharge of water and the existing dikes have to be improved. For this the bank fixation was taken out and placed by gravel banks. To restrain the river within flood corridor, the protection of the bank is replaced by and hidden stone barrier buried in front of dikes, to limit the migration of the river bed in cases of floods, so the dikes will not be damaged. The dikes have to be improved for the 100 year flood. The sections, covered with trees, got enforced by placing a mixture of concrete and bentonit, armed with steel pylons into the dikes.

Hydraulic modelling
The widening of the river bed improved the deposits for gravel, so the gravel banks, a natural part of alpine river systems are back again even in the city, changing their position with each flood. The remodelling of the river canal and the floodplain opens the access for people to the water edge. To make sure that these measurements will resist flood, a hydraulic model in the scale 1:30 was built.

Ecological improvements
The relocation of dykes is a precondition for widening the river bed. It improves the structural variability and with this habitats for plants and animals. Removing weirs and to replace them by ramps brought back the longitudinal connectivity in the river. The sediments, before stabilised by this weirs, now can be transported during floods; the substrate of gravel and sand, now revived, can serve again as spooning places for fishes and other habitants of the river bed.

Fig 5: Weirs for bed fixation are replaced by ramps

Outdoor Recreation
The opening of the river by widening and lowering the bank, getting islands and gravel banks, improves the recreation facilities along the river in the centre of a city with more than one million of habitants. The new Isar attracts during warm and sunny days ten thousands of visitors, bathing in the sun or in the water, celebrating parties day and night. The restored Isar serves a giant public swimming pool, which also means more public toilets and more maintenance of the adjacent land to the river, which is used as a public park during the summer season. These crowds of people, using the river in Munich for recreation, can reach the Isar by bicycle or public traffic. The will not cause traffic to visit and spoil the more natural sections north and south of Munich with their high value for nature conservation, especially with their habitats for rare and protected species of plants and animals.

Hygienic situation
Since 2005 the Isar in Munich offers in normal days bathing water quality, as this is ask by the European directive for water bathing quality. To achieve this, the sewage treatment plants between the Alps and Munich are running from April to October UV-radiation, which treat the out flowing water. This radiation reduces the bacteria during normal flows for about 50 %. This is possible, because more of 50% of the watershed south of Munich is covered by forests, pressures of agriculture, industrial

zones and population are in this part of the watershed relative low. The City of Munich put up a program to reduce the storm water flow into the Isar.

Construction processes
The planning and construction processes were closely watched by the public. Information was given to the local districts, neighbouring the Isar, the Isar-Alliance and to the general public.

The construction work was done during October and April, starting 1999. This is the time, where the discharge of the Isar to its alpine watershed is low, snow and ice in the mountains and also the pressure of recreation is less. The first section of the restoration work was done in a pilot project to get experiences with these new steps in river restoration. Especially the modelling of the new bank and floodplain needs a sensitive under-standing. To protect bed erosion the old weirs were replaced by ramps developed for alpine river systems. Workshops and excursions were organised to exchange experiences and improve the technical solutions.

Flood 9/2005 and maintenance costs
The planners have to find a solution combining the technical standards for flood control, ecological needs and demands for outdoor recreation. A high flood occurred in 9/2005. The new Isar passed successful this test, with a discharge more than 1100 m3/s. With this flood gravel was transported without problems through the redesigned sections. But a huge amount of trees, shrubs and wooden debris were deposited at the gravel bank and has to be taken away. But this has also been always occurred after floods, even before the Isar was restored.

The city of Munich is responsible for the maintenance for the Isar. The cost for the flood corridor, which is comparable to a public park or a public swimming pool are slightly higher than before, but the new Isar a park and a bathing area all over the year attracts more guests than ever before.

Fig. 6: The new Isar, an attractive river landscape and place for outdoor recreation.

2.2 River Restoration: Isar south of Munich, near Icking
South of Munich the Isar flows in the floodplain within a corridor of alluvial woodland. The water of the Isar is taken in canals to generate electricity. For this purpose that Isar-section got canalized between 1923-1927 with negative impacts to the hydro-morphological processes; the once dynamic system got more static, most of the hydro morphological processes like migration of the river bed with erosion and sedimentation were restricted. The concession expired 1997.

To get a new concession, the power company was asked to raise the minimum flow, to restore the river and to contribute to the cost restoration 50 %, based on a river restoration concept. The concept for river restoration demanded:

- to readmit the hydro-morphological processes by taking out the bank protection and
- to install a bypass for the longitudinal connectivity at the weir
- to improve outdoor recreation near bridges with accessibility to the river,
- to offer parking possibilities and public toilets and
- to put up an information system with the subjects culture, technique and nature.

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Restoration costs:
Approx. 2.5 Mio € for removing the bank protection (the concrete stone protection was shredded and given back to the river to enrich the gravel transport). Approx. 200.000 € to build a bypass at the weir in Icking for the longitudinal connectivity. Not included in these costs is the land, given back to the

river, since this land is owned by the State of Bavaria. Also not included are costs for the loss of energy, since the new permission 1997 the minimum discharge in the river is raised from 5m³/s to 15 m³/s.

Fig. 7: The Isar near Icking: the maps from 1798, 1925 and 1986 showing the changes of the river system and gravel banks due to river construction.

Fig.8: River restoration in progress at the Isar near Icking before and after the restoration. With the, removal of bank fixation in winter 1999/2000 – the large floods 2002 and 2005 accelerated the restoration process. Photo: Joven, Munich

2.3 River restoration: Isar, north of Munich

The Isar flows from Munich north to Landshut in a woodland corridor of more than 3.500 ha and a length of about 70 km. The once braided river system was canalized between 1910 and 1930 and a canal was built about 1925 to use the hydropower. The concession expired 2001 and got reviewed. The power company had to rayise the minimum discharge in the river between 13m³/s and 17m³/s (seasonal) and has to pay 20 Million Euros within 10 years for restoration works, which will be done by the state and subsidies by the EU. The basic for this agreement was a river restoration concept. The objectives are the same like at the Isar south on Munich, near Icking. They include:

- to improve flood control
- to replace weirs by ramps to improve the longitudinal connectivity and
- to take out bank fixations

The project includes building new dikes at the edge of the woodlands with the standards of today. The old dikes are given up. The retention area during floods gets enlarged from 1 600 ha to 2600 ha.
The bank fixations are taken out to start again hydro-morphological processes of erosion and sedimentation in the once braided river system. The biodiversity of the alluvial flood plain, which has also the status of Natura 2000 will be raised. The land is own by the State of Bavaria, who is also in charge for the river maintenance and is doing the work. .

Fig. 9: Restoration concept for the Isar, north of Munich. By relocation of dykes the present floodplain will be enlarged from 1600 ha to 260o ha

Outlook

The case studies along the Isar are showing what can be achieved by river restoration. In such projects flood protection, ecology, recreation and nature conservation (Natura2000 areas) can be combined in win-win projects. The sustainability of such projects, done by an engaged team of engineers, landscape architects, supported by stakeholders and public participation through all decision making levels is long lasting. Given more space to the river means to improve the natural retention potential and to reduce the ricks, which can be caused by floods. To bring back the hydro morphological processes improves the ecosystem with its biodiversity and reduces the costs for maintenance. Last not least the population in the urban and rural areas get back a river, showing again its natural character, offering recreation facilities and also the beauties and secrets of nature. The precondition for the sustainability of rivers is, besides the knowledge and the experiences of the experts and the understanding of the public, finding win-win situation "to give space back to the rivers".

Fig. 10: The alluvial forests along the Isar north of Munich during the flood 2005. They are important for the retention of water during floods, nature conversation and outdoor recreation

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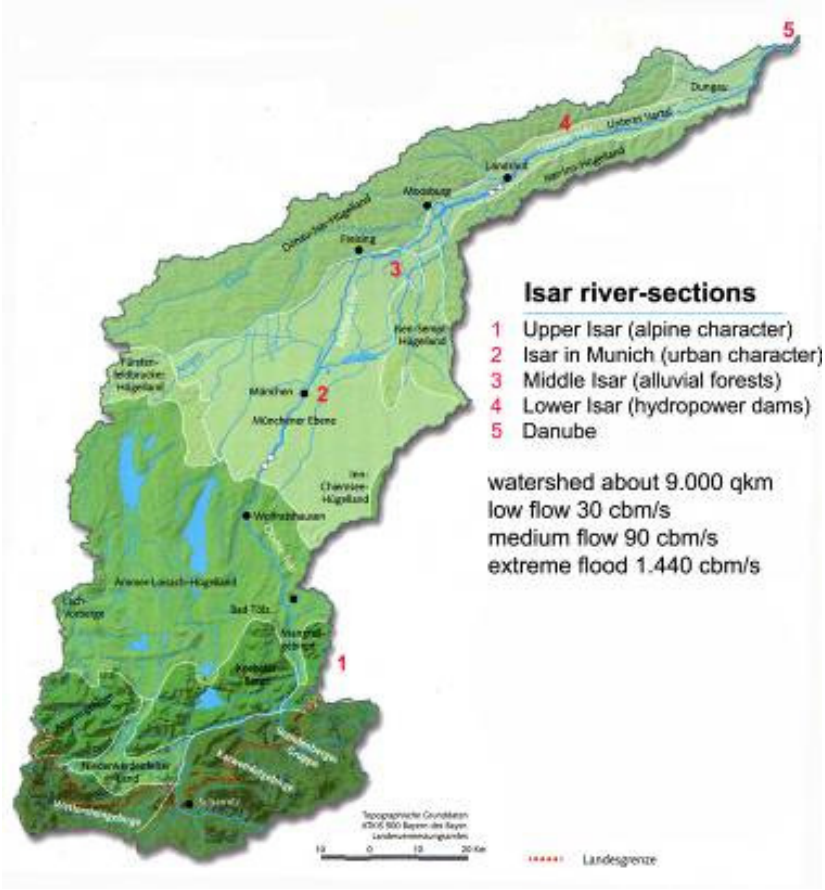

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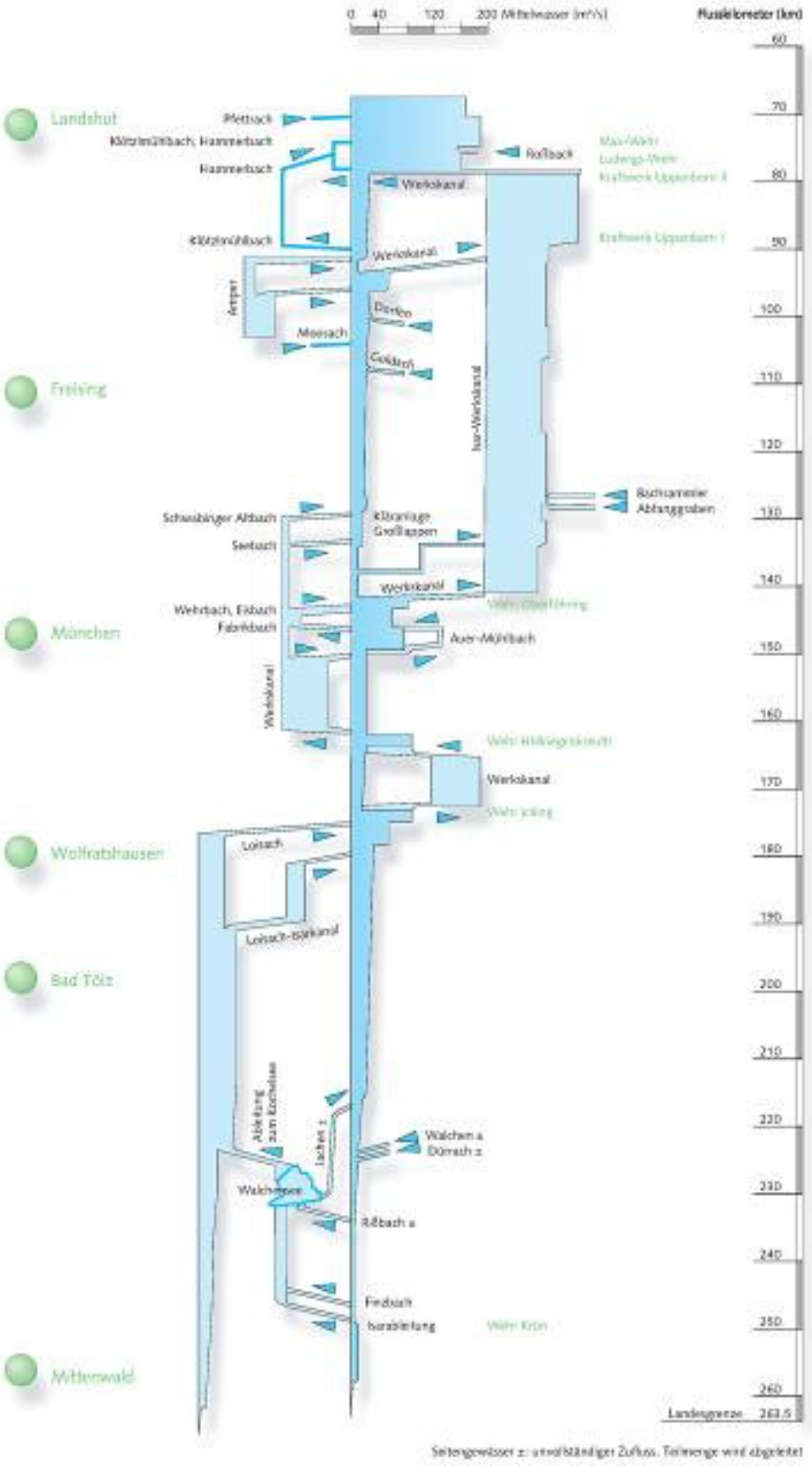
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Flusskilometer (km)
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Freising
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Hammerbach
Kötzlinger Bach
Werkskanal
Amper
Moosach
Goldach
Isar-Werkskanal
Schwaiger Altbach
Sweibach
Kläranlage Großlappen
Rechenanlage Abfanggraben
Wehrbach, Eisbach
Fabrikbach
Auer-Mühlbach
Loisach
Loisach-Kanal
Walchen a
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Rißbach a
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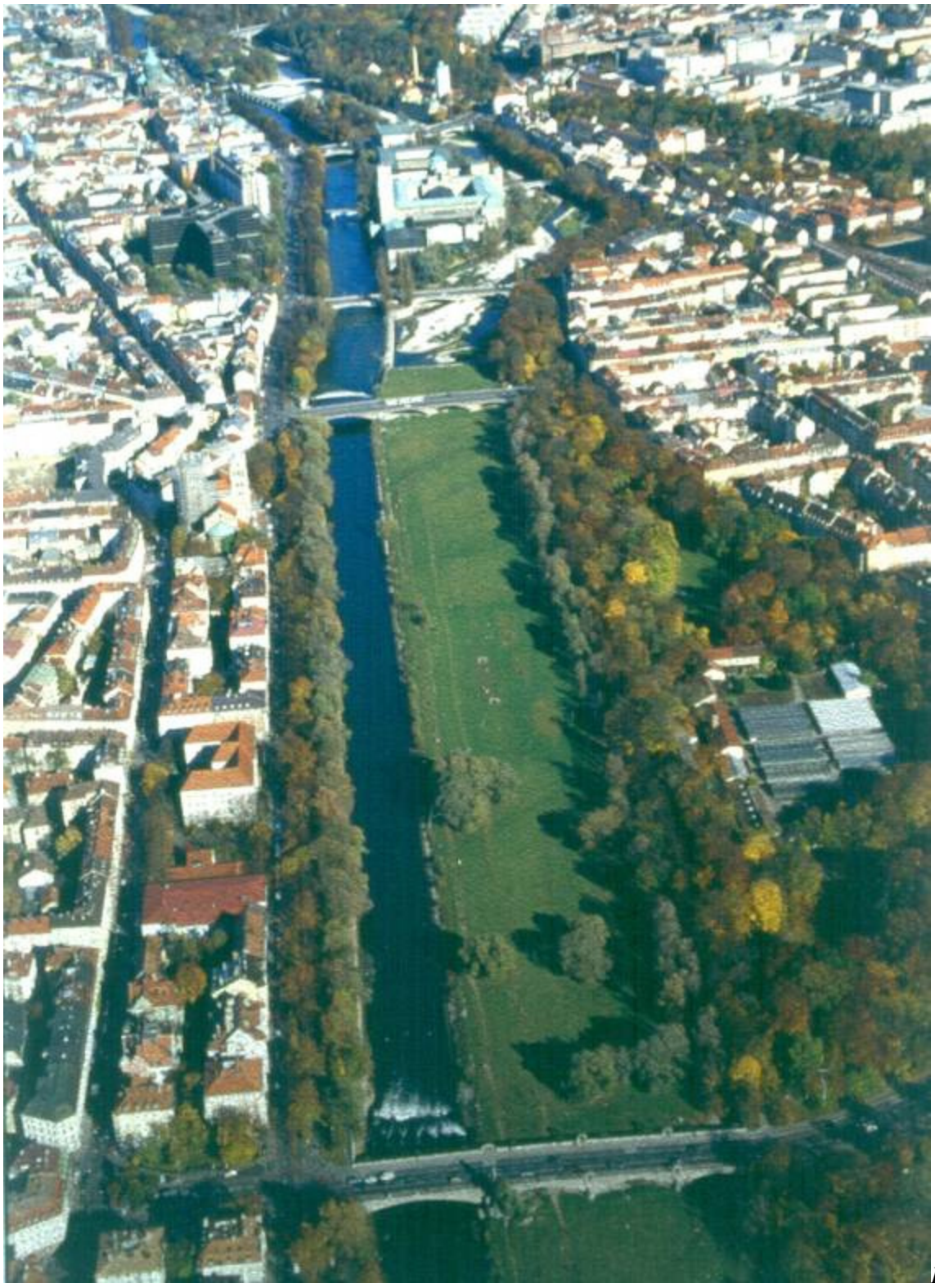
Fig: 3 Diagram of water extraction along the Isar between the Alps and Landshut for hydropower



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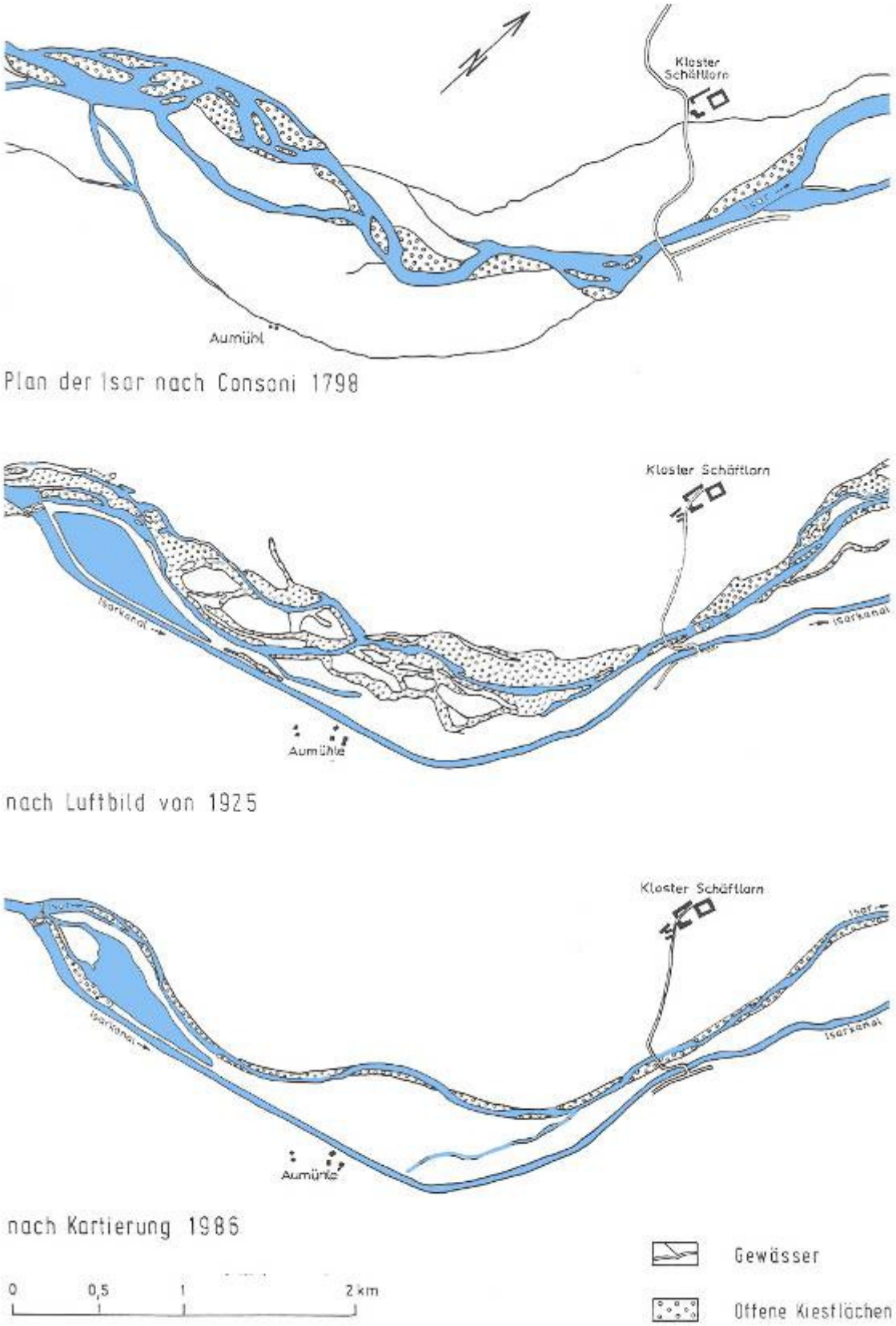

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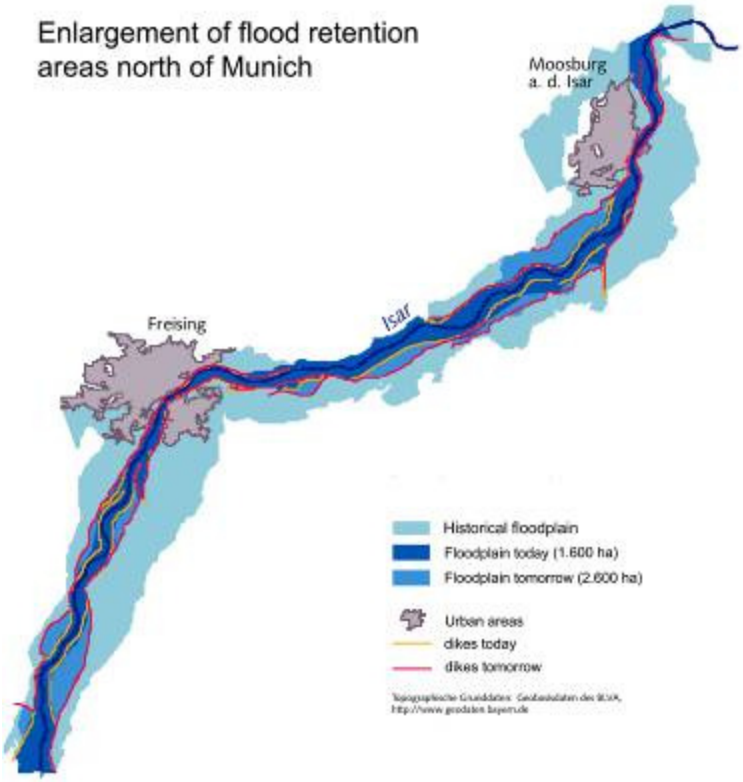

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