Urban River Basin Enhancement Methods

Work Package 3: Study Site Monitoring

Deliverable 3.2

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Executive Summary

Work Package 3 (WP3) of the URBEM project forms a major part of theme 3 (New Tools to assess the potential for urban watercourse rehabilitation). The objective of this theme is to develop ‘tools’ which can help urban planners and environmental and local authorities to identify which reaches of urban watercourse are most suitable for rehabilitation. Five urban river sites across Europe have been identified as research study sites for URBEM (Chaudanne, France; Ljubljana, Slovenia; Ouseburn, United Kingdom; Weidigtbach, Germany and Wien River, Austria) as part of this theme.

The data collected since the start of the project covers five areas (Hydrological Regime, Channel Geomorphology, Water Chemistry, Biology, Social and Economic Well-being attributes) and is stored in a MS Excel spreadsheet.

The completeness of the dataset is assessed through a simple classification method and a single histogram summarizes the current status of the data submitted to WP3 for each partner. An interactive spreadsheet is created for the Ouseburn as an example of delivery for work package 11.

A nested framework approach with different spatial scales available (catchment, river stretch, habitat) is proposed for the last year of the project, where the current database, the interactive spreadsheet and a future relational database will support URBEM framework. The MS Access database will extract from the Excel database the relevant data and spatially relate it to different spatial scales (catchment, river stretch, etc). For example, common catchment characteristics (catchment area, annual average rainfall, etc) and river stretch (river stretch length, water quality, etc) could be extracted from the current dataset.

The current dataset is available on URBEM ftp site, case study partners can access it and submit to UNEW any necessary amendment or changes. The current version of the dataset is not regarded as the final version as the application of WP6 will certainly trigger a new perception of how to present the current data to the end user partners.

Abbreviations

CIS	Common Implementation Strategy
CSO	Combined Sewer Overflow
EA	Environment Agency
QE	Quality Elements
WP	Work Package
WFD	Water Framework Directive
REFCOND	Reference Condition Group
UNEW	University of Newcastle

Contents

1. Introduction

The URBEM project aims to provide new tools, techniques and procedures to enhance watercourses located in urban areas. These tools should provide enough scope to cover differing, multi-functional uses of urban watercourses and their adjacent communities across Europe.

Work Package 3 (WP3) of the URBEM project forms a major part of theme 3 (New Tools to assess the potential for urban watercourse rehabilitation). The objective of this theme is to develop ‘tools’ which can help urban planners and environmental and local authorities to identify which reaches of urban watercourse are most suitable for rehabilitation. Five urban river sites across Europe have been identified as research study sites for URBEM as part of this theme.

Work Package 3 involved collection of existing data and new data from the study sites in order to provide data that can be first analysed and then fed through Work Package 5 (Tool for assessing potential for rehabilitation).

In order to manage such large sets of data and to provide an output that can be used by all partners it was decided that spreadsheets would be the best way of storing the data available for each site. Microsoft Excel was the chosen package to achieve this.

The final database is seen as a ‘work in progress’ document and its easy utilisation guarantee a straightforward updating process throughout the whole duration of the URBEM project.

2. Description of study sites

2.1 Chaudanne – Lyon, France

See appendix 8.1

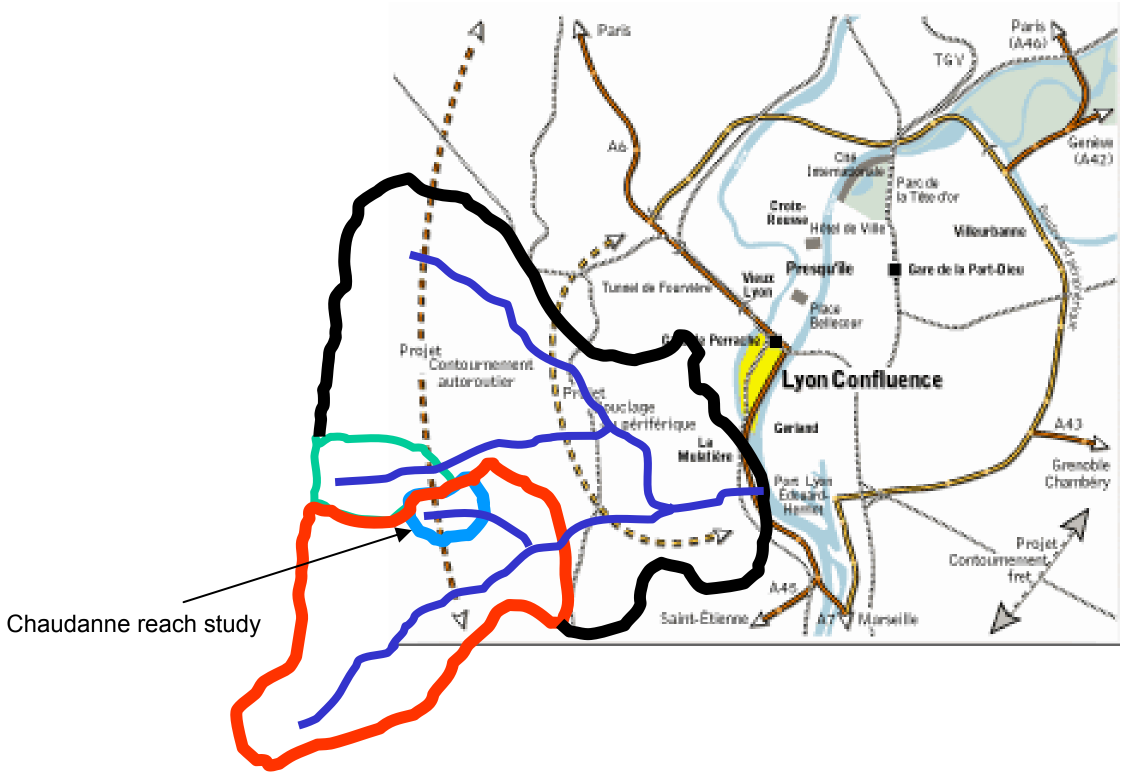

Fig. 1 Chaudanne catchment

The site chosen for France is the Chaudanne, located in the Southwest part of Lyon, Southeast of France. The reach that was chosen for study is located in a residential area, 15km from the city of Lyon. The main issue is combined sewer overflow during wet weather. The increase of imperviousness during the last decade led to an increase of stormwater flow. Rehabilitation of the river is to be supported by three storm water detention basins which are expected to reduce peak flows and volumes from the combined sewer overflows by a rate of 20%. The rehabilitation operates since January 2004. The river is also impacted by runoff from a car park within the reach studied.

Data has been collected from two monitoring sites located up- and downstream of the sewer overflow since January 2002. The length of the reach studied is 132 m located 2500m from the source of the Chaudanne.

The Chaudanne is seen as representative of the whole basin as for the last thirty years, the impervious areas have increased from 11 to 20% with several new point pollution sources.

2.2 Ljubljana, Slovenia

See appendix 8.2

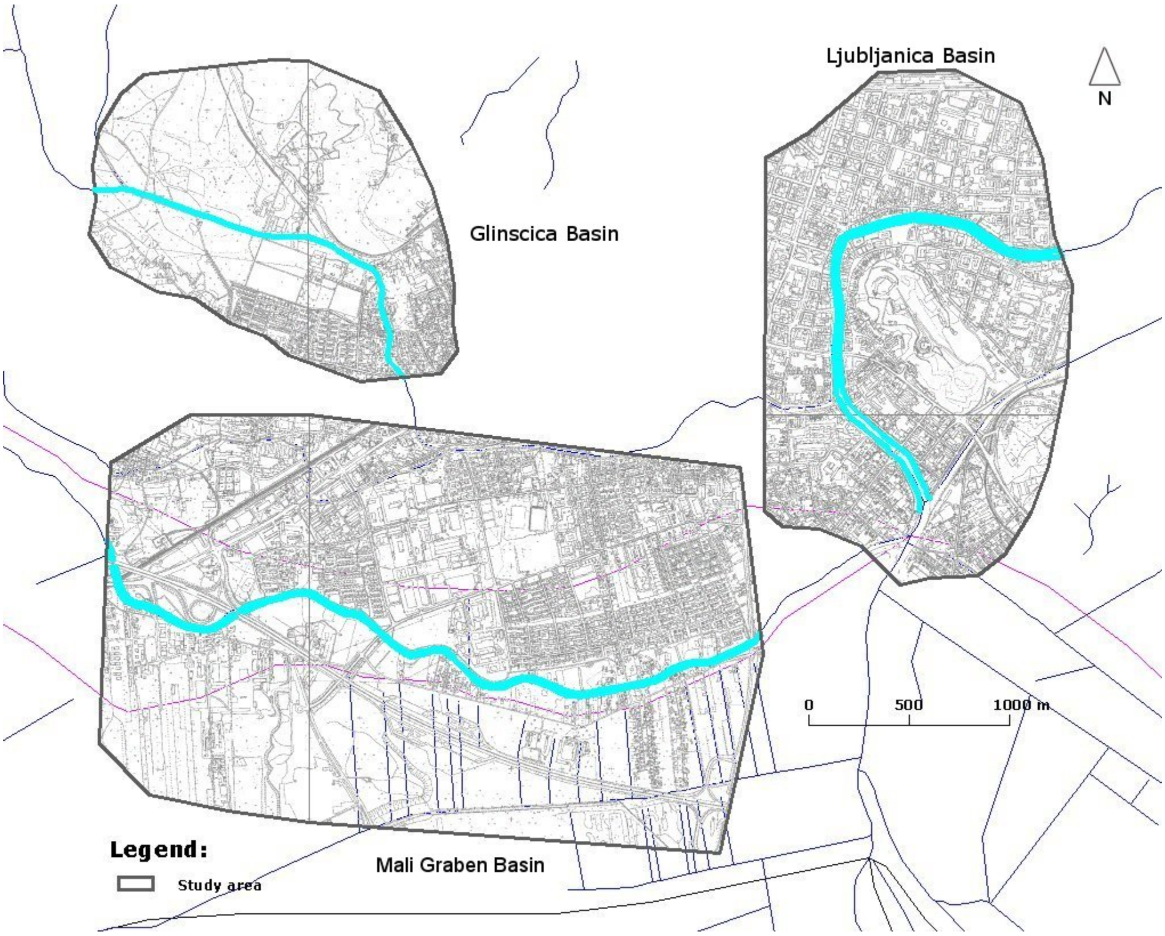

Fig. 2 View of Ljubljana and the three monitored rivers stretches (Glinščica, Mali Graben and Ljubljanica)

The monitoring sites chosen for Slovenia are the three rivers flowing into Ljubljana (central part of Slovenia) from the north: Mali Graben, Gradaščica and Glinščica rivers**.** The Gradaščica River basin spreads in the transitional area from the Dinaric into Alpine region in the central part of Slovenia. The headwater section flows through the varied mountain relief of the Dolomites, and is carved with numerous ravines and valleys. The Gradaščica River basin comprises an area of 154.4 km^2 with an annual rainfall between 1600 and 1700mm. At the Bokalce dam, the Gradaščica splits into two water bodies, the Mestna Gradaščica and the Mali Graben, which flow into the Ljubljanica River (Fig. 2). The Bokalce dam controls the discharge to Mestna Gradaščica stream and only about 10 % of discharge of the Gradaščica River diverts to the Mestna Gradaščica stream. The Mali Graben carries in total about 90 % of discharge of the Gradaščica River. The Glinščica is a tributary of the Mestna Gradaščica.

The land cover of the study areas consist of continued and discontinued urban buildings, industrial units and roads; green urban areas, sport and leisure facilities; agricultural areas consist of non-irrigated arable land, pastures, complex cultivation patterns and land, principally occupied by agriculture, with large areas of natural vegetation (forests include broad-leaved forest, coniferous forest and mixed forest). The river has been extensively modified for flood protection through consolidation of the banks and river bed with artificial materials (e.g. concrete, paving and asphalt).
The study areas are sub-catchments of the water bodies of the Mali Graben, Ljubljanica and Glinščica. The three sub-catchments are close to the city centre and heavily urbanised.

Mali Graben

The Mali Graben is a continuation of the Gradaščica River in its downstream section. In the past, the course of the Mali Graben was situated apart from the urban area of the city of Ljubljana. Due to the fast development of the city that eventually grew into an important cultural, political and economic regional centre, the Mali Graben became the boundary between the managed urban space and the green urban space on the periphery. During the last two decades, the urbanization spread to the right bank of the Mali Graben. Next to the city's southern by-pass at Cesta dveh cesarjev road emerged an industrial zone. To a large extent, the population distribution increased with the rise of several new residential areas (Sibirija, Rakova Jelša) and in the vicinity of these settlements, new residential areas on both river banks have been built. It is anticipated that these areas of Ljubljana will face further building expansion. The length of the study reach is 3,750 m, within the study reach the Mali Graben is partly polluted with litter and other pollutants (occlusion of alluvial waste material because of the intensive riparian vegetation). Flood vulnerability of the urban areas in the Mali Graben river corridor is high. University of Ljubljana estimates that the area of a 100-year flood event spreads over 75 % of the urbanised part of the river corridor.

Glinščica

The catchment area of the river Glinščica comprises 19.3 km^2. In terms of morphology, the valley profile type is mainly a large broad floodplain, except at the joint of the river Glinščica corridor with the slopes of the Rožnik hill. In the downstream part of the study area, the river corridor is more densely urbanised. The degree of the disturbance of natural dynamic processes in the river Glinščica corridor is high and remains mainly unchanged along the entire study reach. The bottom of the river Glinščica channel is paved with concrete plates. The length of the study reach is 2150 m. Flood vulnerability of the urban areas in the Glinščica river corridor is high. University of Ljubljana estimates that the area of a 100-year flood event spreads over 75 % of the urbanised part of the river corridor.

Ljubljanica

At the entrance to the city, the Ljubljanica River had low and unfortified banks, and the area was subjected to floods. To reduce the floodrisk, the diversion channel was excavated in the period from 1772 to 1780 between the Castle hill and the hill of Golovec according to the plan of a Jesuit, Gabriel Gruber. Later, the regulation and deepening of the Ljubljanica River channel was carried out in the reach of the river through the Ljubljana city centre. The image of the river changed drastically between 1913 and 1918, when banks on the river section through the city were heavily reinforced with high concrete walls. The plan for regulation was developed by engineer Alfred Keller. The natural Ljubljanica River channel was transformed into a ditch, which alienated the river body from the city life. Flood vulnerability of the surrounding urban areas in the study area was high in the past. Intensive regulations of the Ljubljanica River channel (widening of the cross section, deepening and introduction of the water barrier) and the excavation of the Gruber channel (diversion of the water away from the city centre) have diminished the flood vulnerability. University of Ljubljana estimates the area of a 100-year flood event spreads over 25 % of the urbanised part of the river corridor.

2.3 Ouseburn – Newcastle-Upon-Tyne, UK
See appendix 8.3

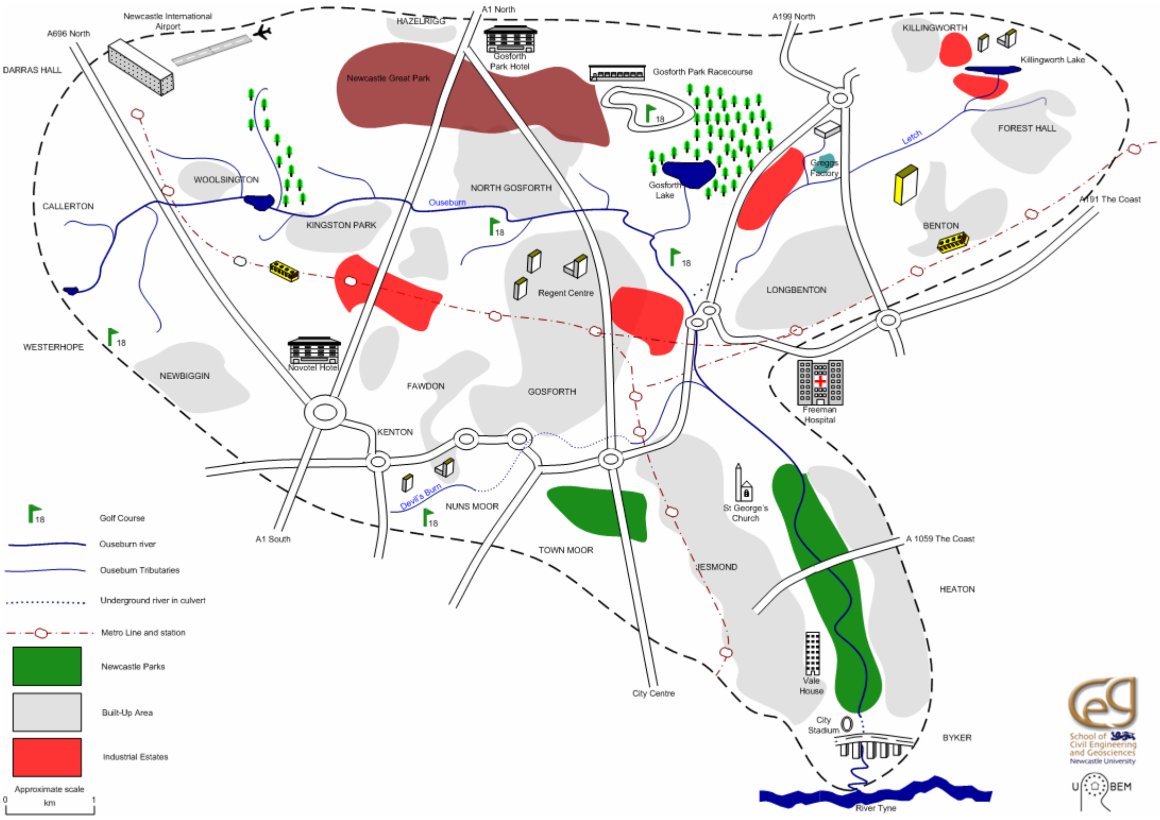

Fig. 3 Perceptual Ouseburn catchment map

The river chosen for the UK is the Ouseburn which is located in Newcastle upon Tyne in the North East of England. The Ouseburn is a left bank tributary of the river Tyne with a catchment area of approximately 62km^2. In its upper catchment the river flows easterly through predominantly rural, agricultural areas, before making a southerly shift and flowing through the Grange, South Gosforth, Jesmond Dene, Sandyford and Byker wards of Newcastle-upon-Tyne. Parts of Newcastle city centre and much of it's residential areas, Jesmond Dene, the Town Moor, Gosforth Lake and Newcastle Airport are some of the more prominent features located within the catchment (Fig.3). The river is tidal for approximately 1km upstream of its confluence with the Tyne creating an estuary environment running through the Lower Ouseburn Valley.

Flooding incidents have occurred over the past 30 years and the flood risk areas are disparate and spread over the entire catchment. There are 22 consents to discharge into the river, 17 to freshwater and 5 to the estuary and the drainage is predominately through combined sewer overflows (CSO's) systems. Important discharges that are not consented include agricultural run-off in the upper part of the catchment and highway drainage throughout the catchment. Historically the airport has caused significant problems in the river with the drainage of de-icing products (before 2000 liquid glycol and granular urea, now based on potassium acetate). Since 2000 the de-icer has drained to a lagoon that has a consent with limited biochemical oxygen demand and ammoniacal nitrogen. Depending on the electrical conductivity, the waters are either pumped into sewers or released into the river.

Regeneration of the Ouseburn has centred upon the Lower Ouseburn Valley. Through Single Regeneration Budget funding, this process was started with a series of projects including accommodation, employment and leisure facilities. Future regeneration is expected to focus upon river enhancement which could improve the amenity value of the area directly, as well as providing a catalyst to more rapid regeneration. An application for permission to install a barrage near the Tyne confluence is currently been examined and its output will be known before the end of 2004.

Water Quality data is available for six sampling sites from January 1989 to July 2004. Only one site (Jesmond Dene) has a longer record (1973-2004). The Environment Agency (EA), the Agency responsible for water quantity and quality in England, provided the data on request. The EA dataset is extremely extensive with more than 60 parameters assessed over 30 years.

2.4 Wien – Vienna, Austria

See appendix 8.4

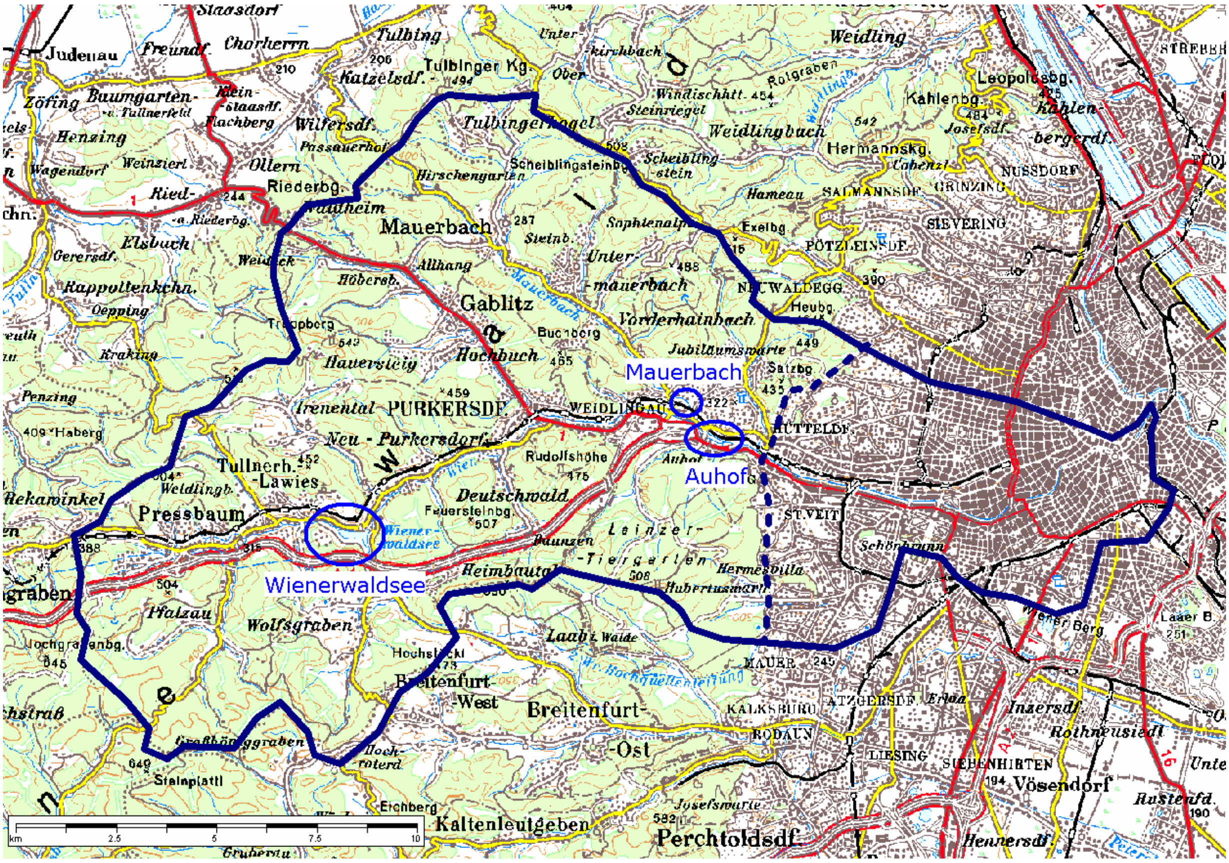

Fig. 4 Wien river catchment map (BEV, 1999: ÖK 200)

The River Wien in the city of Vienna has been chosen as the site for Austria. The specific study site within this river basin is the rehabilitated 2,7 km-long reach close to the Mauerbach-Wien River confluence (Fig.4).

The river has been altered mainly by flood protection schemes consisting of flood control basins Auhof and Mauerbach, the Wienerwald water supply reservoir and hard regulation of the urban river reaches, which were undertaken in the years from 1895 to 1902. These schemes were later found to be inadequate for retention requirements due to insufficient storage volume and control capacity. Pollution sources on the river consist of urban runoff as CSOs and formerly, discharge from a waste water treatment plant.

Rehabilitation of the river has been undertaken during the period from 1995 to 2005. The main aims of these works were to provide enhanced flood protection, to improve the ecological status of the river and to enable public access to the river banks and the river. Upgrading of the Auhof flood storage scheme was completed in 2001 and this included re-design of the basins to improve the ecological status. Similar alterations of the Mauerbach basins were completed in 1998. The municipality of Wien intends to continue rehabilitation on the entire urban river reach within the next ten years to complete the whole process for 2015.

2.5 Weidigtbach – Dresden, Germany

See appendix 8.5

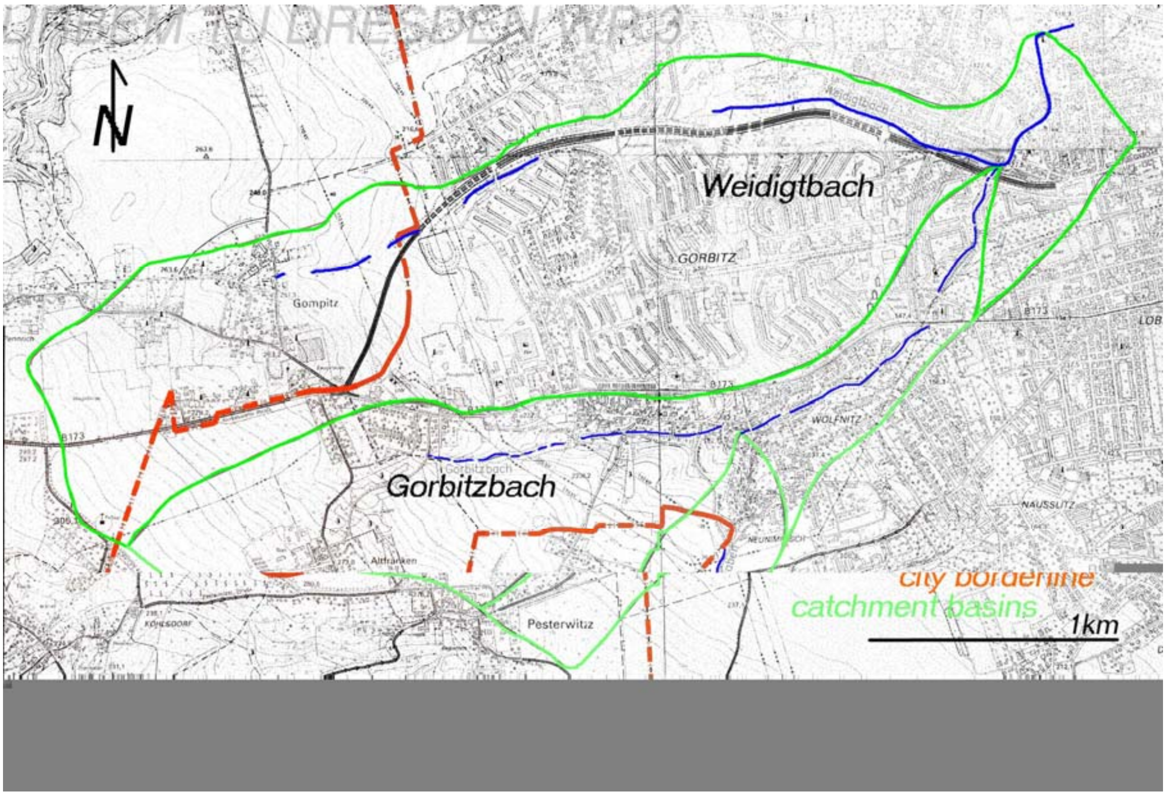

Fig. 5 Weidigtbach Catchment map

The river Weidigtbach has been chosen as the monitoring site for Germany which is situated in the site of Dresden, the main tributary being 3.7 km in length. The river has two main sections. The first section towards the borders of Dresden, is partly culverted within a predominantly agricultural area with small settlements. There are two retention basins and the river suffers from road runoff and agricultural runoff-both diffuse pollution sources. The second section is from the borders of Dresden to the mouth. The land use in this section is urban and in most cases extends to the river banks. Almost all the tributaries are culverted, the river has a hard engineered bed and the stream mouth has been split for flood prevention.

Rehabilitation of the river is to be completed by 2006. This will involve the re-naturalisation of the river with mitigation measures for a new road. Table 2.1 sums up the objectives of the different case studies and table 2.2 classifies the different river stretches using the Water Framework Directive classification scheme.

	Rehabilitation Objectives
Chaudanne	Reducing by half both peak flow and volumes coming from the Combined Sewer Overflow using stormwater detention basins
Ljubljana	Flood issues and water quality issues impacting on the fish population in the Ljubljana urban rivers (Gradascisca, Mali Graben and Gliniscica)
Ouseburn	Barrage at the mouth of the river to improve the visual appearance of the river (siltation issue) and its water quality in its lower part (CSO's, wildlife corridor). These schemes will permit the regeneration of the lower part of the catchment.
Weidigtbach	Renaturalisation of the bed along the whole river stretch
Wien	Reduce flood hazards in the urban river reach by creating or enhancing three the retention schemes along the river Wien (Auhof, Mauerbach and Wienerwaldsee). The reconstruction of the reservoirs will also serve ecological and recreational purposes

Table 2.1 Summary of the different rehabilitation project objectives

Catchment Descriptors	**Chaudanne**	**Glinscica**	**Ouseburn**	**Weidigtbach**	**Wien**
Ecoregion	8 Alps	5 Dinaric Western Balkan	18 Great Britain	14 Central Plains	4 & 11 Alps & Hungarian Lowlands)
Stream Order	1	5	3	2	5
Distance from River source	2.8	8	14	4.7	15.06
Catchment Class (1-4, km^2)	1 (0.283)	1 (17.4)	1 (55)	1 (4.18)	2 (229.5)
Geology	Granite & Shale	Karst	Carboniferous (Limestone & Coal Measures)	Cretaceous Sandstone	Flysch
Altitude Class at the mouth	2	NK	1	NK	1
Altitude class at of 75% of the area	2	NK	1	NK	2
Region	Savoie	Central Slovenia	Tyne & Wear	Saxony	Vienna
Mean flow (l/s or m^3/s)	Intermittent (2 month a year)	NK	$0.29 m^3/s$	10 l/s	$1.07 m^3/s$
Mean Precipitation (mm/year)	750	1368	668	720	610

Table 2.2 Water Framework Directive classification scheme

3. Data collection

Data collected during the first two years of the URBEM project has been collated into a spreadsheet consisting of 5 pages:

- Hydrological Regime
- Channel Geomorphology
- Water Chemistry
- Biology
- Social and Economic Wellbeing

Data Categories	Data required	Frequency
Hydraulic Regime	Rainfall Flows/discharge	Monthly
Channel Geomorphology/ Cross Section	Channel width Channel Length (of each sampling section) Channel slope Bank slope Bank material Cross Sections (in data form, illustrations would be helpful) Sediment characteristics	One data set before and after rehabilitation
Water Chemistry - this will depend largely on the type of pollution affecting the river which is indicated in brackets after the variable)	pH (all) Conductivity (all) Suspended solids (all) BOD/COD (all) DOC (all) Heavy metals (urban runoff/road runoff/ mine water discharge/ industrial effluent) Nitrogen forms and phosphate (agricultural runoff/ sewage overflow/ urban runoff) Other elements e.g. Ca, Na, K (agricultural runoff/ mine water discharge)	Monthly
Biological data	Benthic invertebrates data. (with detailed methodologies provided)	Bi-annually
Social and Economic Data	Crime Rate, Accident Rate, Flood Risk, Employment Rate, Housing Costs, Development of Housing, Investment, Migration Balance, Property Values, Number of Visitors, Riverside, River Crossings, Resources, Spaces, Odours, Visitors, Leisure ,Recreation Passive and Recreation	One data set before and after rehabilitation

Table 3.1 Summary of the type of data collected for each site

The collection was done in two steps, the first entailing collection of existing data and the second new monitoring data (to complement the first data collection). Thus was to ensure that a sufficient data quantity and quality was available to WP5. The first step took place between months 4 and 11. The existing data was then presented during the URBEM meeting in May 2004. After the meeting in Wallingford, the University of Newcastle and HR Wallingford agreed that the existing collected data would be sufficient to feed WP5 but not to permit a comparison between the different sites and that the new monitoring data will consist of images and GIS files to include in the common databank available on the FTP site.

During summer 2004, all the partners have either updated their existing dataset or sent relevant images and GIS files. The spreadsheet database was updated at the end of August 2004.

Data collected for each case study for each set of parameters is displayed on a separate page. The river name and the section to which the data applies are given in the first 2 columns followed by the relevant data. A spreadsheet was chosen principally to enable ease of data transfer between partners and between work packages. A spreadsheet allows for analysis of data, in particular for sorting, searching and filtering data.

It is clear that there is broad variability in the existing data collected from the sites. In the majority of cases there are 1 or 2 sampling sites and either 1 sampling data or the material provided is as average values. This will cause problems with analysing the existing data (short monitoring period, small number of parameters monitored, etc) and the relevance and wide applicability of the proposed ranking method to other dataset can be seen as questionable.

Table 3.2 shows the current state of the data collection and highlights the problems for the data analysis component of Work Package 3.

Data categories	Chaudanne	Ouseburn	Ljubljana	Weidigtbach	Wien
Rainfall - Flow	Daily Rainfall/Runoff for the period 01/2002-09/2004 Average Annual Rainfall	92-2004 Rainfall Data Flow rating curve at Jesmond Dene Flow data available Average Annual Rainfall 61-90	None	Average Annual Rainfall No Rainfall/Runoff data	1997-2001 Monthly Rainfall data for 12 sections Average Annual Rainfall 61-90 for 9 stations
Water Chemistry	June 00 –April 04 (4 stations) Station 1 (11 sampling over 4 years) Station 2 (11 sampling over 4 years) Station 3 (2 sampling in 2004) Station 4 (1 sample in 2004)	Monthly sampling for six stations Ouseburn Tributary-Aiport (1989-2004) Woolsington (1990-2004) Brunton Bridge (1989-2004) Three Mile Bridge (1989-2004) Castle Farm (1989-2004) Jesmond Dene (1973-2004)	Glincisca 7/03 – 10/03 14 sites 3 to 6 sampling on these two days	Sep 01 (19 sites) & May 02 (4 sites) 2 sampling date	2001 & 1993-2003 (2 stations, average annual values)
Water Biology	10/03/03 –10/04/03 Benthic invertebrates data Station 1 No data Station 2 (04/03-04/04, 5 dates) Station 3 (04/03-04/04, 4 dates) Station 4 (04/03-04/04, 4 dates) Species List/Abundance	1990-2004 for 5 sites (Benthic invertebrates) Quarterly sampling Jesmond Dene (1990-2004) Brunton Bridge (2000-2004) Woolsington (1995-2004) Salters Bridge (1990-2004) Ouseburn Trib at Airport (2000-2004) Species List/Abundance/ Score	1 sample for six sites During July/Aug 03 Species list/ Abundance/ Score	May 01 & Sep 2002 (19 stations) 2 Invertebrates sample Species list/ Abundance/ Score 1 diatom sample	99-01 (3 samples, vegetation only) 2001 Fish, birds and mammals data No Invertebrates data
Cross-Section	2 cross-sections described in spreadsheet	Section 105 – all along the river (used for river modelling)	None	Spreadsheet describing sections	28 – Image format
Images and Map	In a PowerPoint presentation	Mastermap data Sampling stations, rainguage	-Catchment map -Autocad files -Photographic archive of the catchment	Images of the whole catchment, weir location and sampling stations	In a PowerPoint presentation

Table 3.2 Summary of collected data

University of Newcastle is proposing to create a personalised interactive MS Excel spreadsheet for each partner. The spreadsheet will display the different dataset through an interactive menu on each worksheet and the user will be able to navigate through the different component of the dataset and also learn about the catchment issues. The spreadsheet will be created using Visual Basic for Application, a programming language available in MS Office suite to create complex and dynamic spreadsheet. This spreadsheet will be free to download from the ftp site but could also be available through the URBEM website created for WP11.

4. Data Analysis

4.1 WP3 Water Framework Directive perspective

December 22, 2000 will remain a milestone in the history of water policy in Europe as the Water Framework Directive (Directive 2000/60/EEC) was published in the Official Journal of the European Communities and thereby entered into legislation for every European State Member. This Directive is the result of a process of more than five years of discussions and negotiations between a wide range of experts, stakeholders and policy makers. The Directive establishes a framework for the protection of all waters (inland surface waters, transitional waters, coastal waters and groundwater) in Europe. Overall the Directive aims at preventing deterioration of the status of all bodies of surface water and achieving *good water status* for all water by 2015. For surface waters, *good water status* is determined by a “good ecological status” and a “good chemical status”. Ecological status is determined by biological quality elements supported by hydromorphological and physico-chemical quality element (REFCOND Guidance, 2004).

If the biological quality elements (QE) relevant to good, moderate, poor or bad status/potential are achieved, then by definition the condition of the hydromorphological QE and the physico-chemical QE must be consistent with that achievement and would not affect the classification of ecological status/potential. Table 4.1 displays the different QE recommended by the WFD to use for the classification of ecological status and ecological potential.

<table>
<tr><th>Annex V 1.1.1
Rivers</th><th>Annex V 1.1.3
Transitional Waters</th><th>Annex V 1.1.4
Coastal Waters</th></tr>
<tr><td colspan="3">BIOLOGICAL ELEMENTS</td></tr>
<tr><td>Composition and abundance of aquatic flora
Composition and abundance of benthic invertebrate fauna
Composition, abundance and age structure of fish fauna</td><td>Composition, abundance and biomass of phytoplankton
Composition and abundance of other aquatic flora
Composition of benthic invertebrate fauna
Composition and abundance of fish fauna</td><td>Composition, abundance and biomass of phytoplankton
Composition and abundance of other aquatic flora
Composition of benthic invertebrate fauna</td></tr>
<tr><td colspan="3">HYDROMORPHOLOGICAL ELEMENTS SUPPORTING THE BIOLOGICAL ELEMENTS</td></tr>
<tr><td>Hydrological regime
➢ Quantity and dynamic of water flow
➢ Connection to groundwater bodies
River Continuity
Morphological conditions
➢ River Depth and width variation
➢ Structure and substrate of the river bed
➢ Structure of the riparian zone</td><td>Tidal regime
➢ Freshwater flow
➢ Wave exposure
Morphological conditions
➢ Depth variation
➢ Quantity, structure and substrate of the bed
➢ Structure of the intertidal zone</td><td>Tidal regime
➢ Freshwater flow
➢ Wave exposure
Morphological conditions
➢ Depth variation
➢ Quantity, structure and substrate of the bed
➢ Structure of the intertidal zone</td></tr>
<tr><td colspan="3">CHEMICAL AND PHYSICOCHEMICAL ELEMENTS SUPPORTING THE BIOLOGICAL ELEMENTS</td></tr>
<tr><td>General
➢ Thermal Conditions
➢ Oxygenation conditions
➢ Salinity
➢ Acidification status
➢ Nutrient conditions
Specific pollutants
➢ Pollution by priority substances identified as being discharged into the body of water
➢ Pollution by other substances identified as being in significant quantities discharged into the body of water</td><td>General
➢ Transparency
➢ Thermal Conditions
➢ Oxygenation conditions
➢ Salinity
➢ Nutrient conditions
Specific pollutants
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➢ Pollution by other substances identified as being in significant quantities discharged into the body of water</td></tr>
</table>

Table 4.1 Quality Elements to be used for the assessment of ecological status/potential based on the list in annex V 1.1 of the WFD (ECOSTAT, 2003)

The Quality Elements list used in assessing the current state of the different water bodies is reflected in the data requested for WP3 (Table 3.1) in the last two years. The ranking system devised here is not meant to replace the current WFD assessment although it can apply to other European projects where existing and new data has to be assembled during the whole duration of the project.

4.2 WP3 ranking system

The ranking system of the different partner's dataset is primarily based on the quality of the dataset (record length) and the completeness of each section data requirement. The system can also show the current status of the different dataset, it can quickly identify the missing elements and the deviation from the dataset completion target as shown in table 3.1 through its colour-coded scoring procedure.

4.2.1 Methodology

There are five data categories in the current database; each category refers to a different type of data (cross-sections, hydrological records, physicochemical parameter, etc) requiring different monitoring aspects (frequency: monthly measurement physicochemical parameters, quarterly assessment for benthic invertebrates, etc). Consequently the ranking for each category is calculated differently. Each category will receive a completeness of record score (1 to 5), in a form of five different classes (High, Good, Moderate, Poor and Bad).

Class	Score
High	5
Good	4
Moderate	3
Poor	2
Bad	1

The final score will be given by the probability of class percentage. Each category score represents 20% of the final score and therefore the final score of 100% is made of the score of the five different categories (hydrological regime, channel morphology, water chemistry, water biology, and the socio-economic and well-being attributes).

A tick (✓) is used within a category, where only one nominal value is needed, for example the annual average rainfall in the hydrological regime category.

N/A (Non Available) is used when the data hasn't been provided to UNEW.

The completeness of record row is present in two categories, the hydrological regime and the channel morphology as this is only applicable to categories with nominal attribute value (number of gauging stations, geology, etc) as opposed to multiple values (daily or monthly measurements) found in the other categories. The completeness of record row has only an influence in the final score of these two categories, the three other categories rely on a more scientific method which is explained below.

The highest class percentage for each partner will reflect the current state of the database according to the proposed ranking system. This result echoes the quality and the quantity of the collected data from each partner.

Water Chemistry data

Water chemistry data should be collected over at least three years to reflect inter-year variation with no more than half of the data in any one year. At least two seasons must be represented in each annual data set to reflect inter-seasonal variation with some samples representing warm weather conditions (March 15 to October 15). As a general rule, at least 12 monthly samples or measurement are required at each site in order to determine support of designated uses and identification of water quality concerns (General Quality Assessment, NRA, 1994).

Monitoring length (monthly sample)

1 0-3 samples

2 3-6 samples

3 6-12 samples

4 12-24 samples

5 >24 samples

Water Biology

A quarterly assessment is needed for benthic invertebrates to reflect the inter year variation and the impact of pollution events on the communities. The data record should cover at least three years.

Monitoring length (quarterly sampling)

1 0-3 samples

2 3-6 samples

3 6-12 samples

4 12-24 samples

5 >24 samples

Several assessment methods are used throughout Europe and there is not yet any common method applied to all Member States.

Looking at the data, there are three different methodologies used to assess the river quality:

- Ouseburn: the Biological Monitoring Working Party[1] and the Average Score Per Taxon[2]
- Ljubljana: the Extended Biotic Index (based on the Trent Biotic Index (Woodiwiss, 1964)

[1] BMWPT system is based on the number of taxa (a numerical value has been assigned to 80 different taxa according to their sensitivity to organic pollution)

[2] ASPT is a stable and reliable index of organic pollution. Values lower than expected indicate organic pollution

- Weidigtbach and Wien[3]: the Saprobic index (each zone affords optimal conditions for certain species and the communities of the organisms in turn behave as biological indicators of organic pollution)
- Chaudanne: only the raw data has been given. No score was attached to the collection

The WFD priority list is based on the toxicity, persistence, bioaccumulation potential, human health risk and the monitored and modelled concentration of each substance in the aquatic environment. The substances on the 'Priority List' are to be subject to one of two general targets:

- A progressive reduction of pollution or inputs, or
- A cessation or phasing out of discharges, emissions and losses.

As of May 2003, the Priority List contains 33 substances within three categories:

Priority Hazardous Substances: brominated diphenylether (pentabromo diphenylether only), C10-13- chloroalkanes, cadmium and compounds, hexachlorobenzene, hexachlorocyclohexane (HCH), hexachlorobutadiene, mercury and compounds, nonylphenols, polyaromatic hydrocarbons (PAH), pentachlorobenzene, tributyltin compounds;

Priority Substances under Review: anthracene (PAH), atrazine, chlorpyrifos, di(2-ethylhexyl)phthalate (DEHP), diuron, endosulfan, isoproturon, lead and compounds, napthalene (PAH), octylphenols, pentachlorophenol, simazine, trichlorobenzenes, (1,2,4-trichlorobenzene), trifluralin;

Priority Substances: alachor, benzene, brominated diphenylether (apart from Penta), chlorofenvinphos, 1,2-dichloroethane, dichloromethane,

[3] The Saprobic Index score has been divided by 100. A score of 350 is related to a river stretch between Class III and IV

fluoranthene (PAH), nickel and compounds, trichloromethane (chloroform) (art. 16, WFD, 2000/60/EEC).

Hydrological regime

The hydrological regime category does not need to be assessed in term of quality of data and record length but more on completeness of record. The information present in this section can be seen as general information regarding the river stretch and its catchment. Average annual rainfall calculated over the 1961-1990 period should be included as well as details of storm events if available (rainfall and % of rainfall as runoff if available). If the rehabilitated river stretch covers a large area, the river is sectioned and each section has its own hydrological regime data.

Channel Morphology

The channel morphology category can be seen as a geomorphological audit as it requires description of river banks, sediment transport, bed geometry, etc. Up to now most of the various catchment parameters (catchment area, geology, river section length, etc) were collected but almost no data about sediment load for the different sites were collected during the project. The available data (detailed cross-sections and catchment parameters) cannot be assessed in term of quality of data but more on completeness of record.

Socio-economic and Well-being attributes

The last section of the dataset concerns the socio-economic and well-being attributes and this class of data is collected on a much lower frequency. In the best case scenario, this data collection should be part of an aesthetic evaluation process.

4.2.2 Results

Hydrological Regime:	Chaudanne	Ljubljana	Ouseburn	Weidigtbach	Wien
Annual Average Rainfall 61-90	✓	✓	✓	✓	✓
Rainfall data (Monthly or Daily, number of years)	Daily/3	N/A	D/14	N/A	M/4
Number of Gauging Stations	1	6	2	4	8
Baseflow index	✓	N/A	N/A	N/A	✓
Completeness of record	4	1	4	2	4
Section evaluation	4	1	4	2	4

Table 4.2 Hydrological Regime category evaluation results

The Hydrological regime category contains general catchment descriptors and rainfall data (and storm event details if available). Only Chaudanne provided storm event details and Ljubljana have not sent yet any data during the last two years despite the important monitoring network existing in and around Ljubljana. The data might be made available in the future through the Ljubljana URBEM website (http://ksh.fgg.uni-lj.si/urbemdatasi/).

Channel morphology	Chaudanne	Ljubljana	Ouseburn	Weidigtbach	Wien
Cross-sections	✓	✓	✓	✓	✓
Geology Information	✓	N/A	✓	✓	✓
Sediment Information	N/A	N/A	N/A	N/A	N/A
Completeness of record	4	2	4	4	4
Section evaluation	4	1	3	3	3

Table 4.3 Channel Morphology category evaluation results

The Channel Morphology category includes geomorphological data and typical cross-sections. Geomorphological appraisal of a river stretch is essential to analyse the ecology of the site and its current ecological potential.. There are very detailed cross-sections data from different partners (UNEW with HEC-RAS and ISIS format, Wien with image version of detailed surveyed cross-sections) which could be used in preliminary hydraulic study. Here, the absence of sediment information and land use data made this section less relevant than the next two sections in term of usefulness of data.

Water Chemistry	**Chaudanne**		**Ljubljana**		**Ouseburn**		**Weidigtbach**		**Wien**	
	Sampling number/years covered	Class	Sampling number/years covered	Class	Sampling number/years covered	Class	Sampling number/years covered	Class	Sampling number/years covered	Class
QE	24/4	4	3-6/1	1	180/15	5	1/1	1	N/A	N/A
Other QE	24/4	4	3-6/1	1	180/15	5	1/1	1	N/A	N/A
WFD Priority List	N/A		N/A		3/1 (depending on site)		N/A		N/A	
Section evaluation	4		1		5		1		N/A	

Table 4.4 Water Chemistry category evaluation table results

Water Chemistry category evaluation shows that only Chaudanne and Ouseburn dataset has an adequate amount of data for an appropriate assessment of the river quality. UNEW has been unable to get hold of similar quality data from the other partners due to different reasons: URBEM consortium is composed of a multidisciplinary research groups and some of them (BOKU, Dresden University) are not responsible for the data collection. Data collection from European institutes/research groups is one of the main problems (with data quality) faced during this exercise. Most of the time, the relevant organization (water companies, government authorities, etc) is owner of the data and a monetary fee is needed to access the data.

Water Biology	Chaudanne		Ljubljana		Ouseburn		Weidigtbach		Wien	
	Sampling number/years covered	Class	Sampling number/years covered	Class	Sampling number/years covered	Class	Sampling number/years covered	Class	Sampling number/years covered	Class
Benthic Invertebrates	4/2	2	2/1	1	60/15	5	2/1	1	N/A	N/A
Fish	N/A	N/A	N/A	N/A	No fish sighted	_	N/A	N/A	3/3	2
Flora	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	3/3	2
Section evaluation	2		1		2		1		2	

Table 4.5 Water Biology category evaluation results

Water Biology category is mostly populated with macro-invertebrates data as it is one of the cheapest biological surveys available and its results can give a good snapshot of the river quality. UNEW and CEMAGREF have consequent data in this section but failed in others (flora, fish). Flora data collection can be seen as poor for most of the partners except Wien where a group of ecologist studied this aspect (see appendix section for Wien). The Ouseburn data came from the Environment Agency and there was no flora and fish survey to date, an Environment Impact Assessment study has just been published regarding the lower part of the catchment and will be added to the dataset as soon as the data is made available. CEMAGREF has not conducted a flora survey yet. The low score of this category is explained by the limited number of samples in time (number of years) and space (different river sections) and maybe flora data collection should have been abandoned during the 2-year period.

	Chaudanne	Ljubljana	Ouseburn	Weidigtbach	Wien
Social / Aesthetic Perception	N/A	N/A	N/A	✓	✓
Accessibility	✓	N/A	N/A	✓	✓
Recreation / Leisure	✓	N/A	✓	✓	✓
Public Health and Safety	N/A	N/A	✓	✓	✓
Completeness of Record	2	N/A	2	5	3

Table 4.6 Socio-economic and Well-beings attributes category evaluation results

Socio-economic and well-being attributes category was admittedly seen as the most difficult category to assess by the some of our partners. For example,

	Chaudanne	Ljubljana	Ouseburn	Weidigtbach	Wien
Hydrological Regime	4	1	4	2	4
Cross-sections	4	1	3	3	3
Water Chemistry	4	1	5	1	N/A
Water Biology	2	1	5	1	2
Socio-Economic and Well-being Indicators	2	N/A	2	5	3

Table 4.7 Summary of evaluation results

Weidigtbach river has a section running in a rural area and there was no social data related for this area. For CEMAGREF and Ljubljana, the scarcity of the data collection was due to their incapacity of collecting themselves the relevant data. The Aesthetic evaluation methodology devised by CESUR in WP4 for the URBEM consortium should have perhaps been applied in each case study in order to provide to WP3 a similar and continuous record.

The different scores for each category are amalgamated in a final table from which the final score can be extracted. This score will give a summary of how well the URBEM partner data score in each category. Each category score represents 20% of the final score and therefore the final score of 100% is made of the score of the five different categories (hydrological regime, channel morphology, water chemistry, water biology, and the socio-economic and well-being attributes). For example, Chaudanne has 60% (three categories) of the whole dataset with a score of 3 (equivalent to Good) and 40% (two categories) with a score of 2. When the category scores for one partner do not add up to 100%, the partner didn't provide any data in one of the five categories.

The final table represents the case studies according to their probability of class percentage. The highest class percentage for each partner reflects the current state of the database according to the proposed ranking system. The overall score echoes the quality and the quantity of the collected data from each partner. The whole methodology can also help to identify in which data category each URBEM partners could have done better.

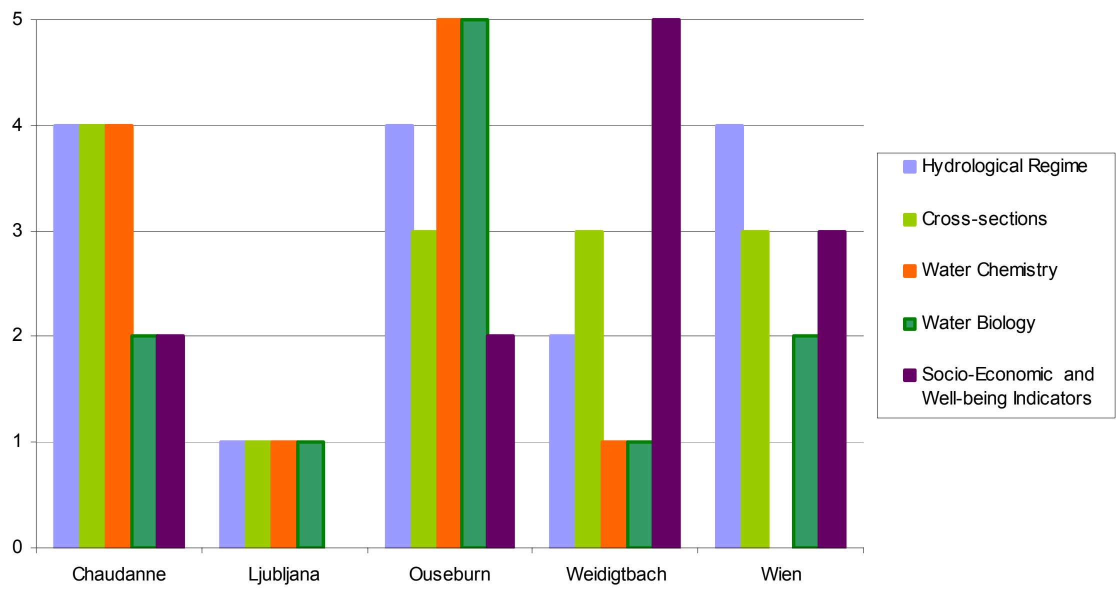

Fig. 4.2 Final result for each partner

	Probability of Class (%)				
	Chaudanne	Ljubljana	Ouseburn	Weidigtbach	Wien
High	-	-	40	20	-
Good	60	-	20	-	20
Moderate	-	-	20	20	40
Poor	40	-	20	20	20
Bad	-	80	-	40	-

Fig. 4.1 Final Results

4.3 WP3 Classification System

URBEM framework aims to deliver an assessment tool to assist the decision-makers in identifying which river stretch within the catchment would be the most beneficial to rehabilitate in terms of environmental and public benefits. WP3 role is to propose a framework contributing to the provision of data on different spatial scales (catchment, river stretch, etc). A relational database will be created in the next year to facilitate the testing of the tool. This database will contain different queries such as catchment and river characteristics (annual average rainfall, catchment area, river stretch length, etc) and water quality data analysis (based on any determinand available within the database). These queries will interrogate the whole dataset and the user will be able to compare the different parameters between the different case study sites in time and space (if several river sections of the same river are present in the dataset). The database will be created from the dataset and will require low maintenance and will be straightforward to update.

5. Data presentation/Future of the data

Since May 2004, Wien, Weidigtbach and Chaudanne have sent more than 100MB of data consisting of images, aerial photographs, pre and post rehabilitation pictures, etc. This extra data is to be combined with the case studies data in an interactive MS Excel spreadsheet. The spreadsheet will introduce the URBEM river rehabilitation schemes with their issues as well as providing access to the raw data.

The URBEM website maintained by HR Wallingford may host the internet version of the spreadsheet (using Java programming language) or just provide the facility to download the case studies spreadsheets. Every Framework 5 projects have the obligation to maintain a project website for at least two years after the end of the project; this could be an opportunity to keep the datasets updated when new monitoring data becomes available.

5.1 Interactive Spreadsheet

Microsoft Excel incorporates a programming language called Visual Basic for Application (VBA). VBA is an object-orientated language, a simplified version of Visual Basic but robust and easy-to-use programming language. Each object has properties and characteristics and can contain several objects within. Figure 5.1 shows a complex useform presenting the issues for the Ouseburn catchment. This Userform is composed of multi-pages, each of them containing some text and images. Each page is an object within the useform and the Microsoft Excel Visual Basic Editor made it easy to add or delete pages from the userform. Other objects present in this userform are:

- “Close button” object is associated with each pages of the Userform
- “Label” object used to describe the image(s) on the page
- “Image” object to illustrate the issues

Fig. 5. 1 Catchment issues Userform

The different pages are accessed by clicking the tabs at the top of the Userform. The number of pages is not limited and each object can be removed or displaced in the VB editor (accessible from Excel by pressing Alt + F11)

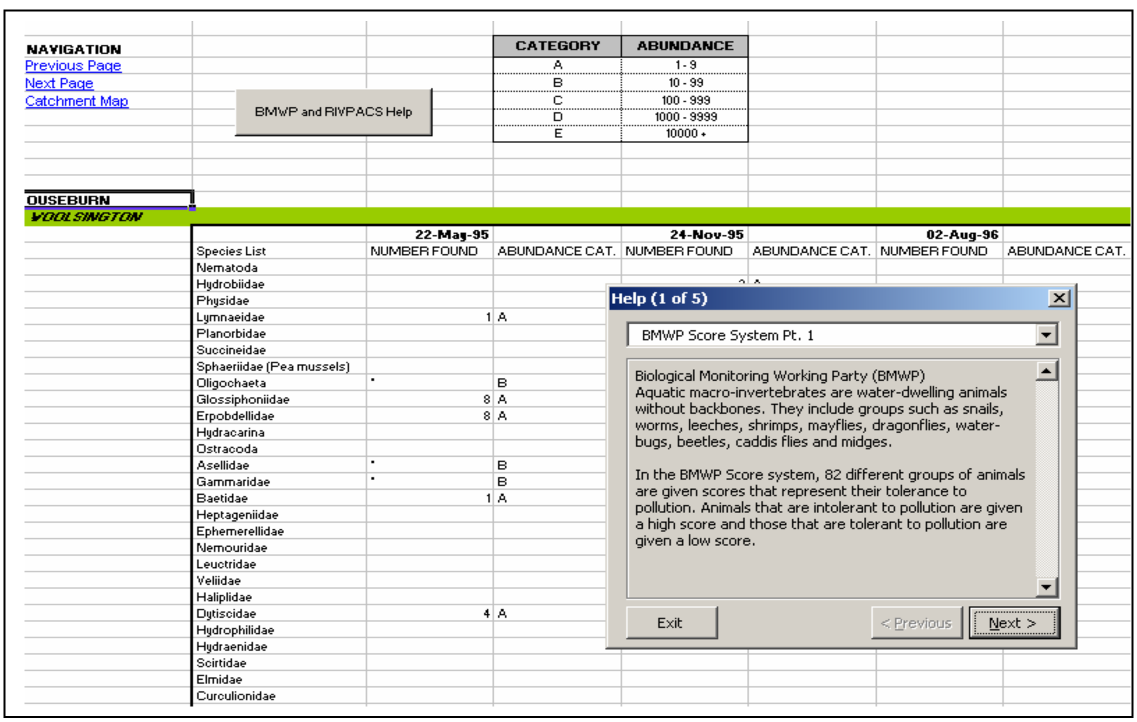

Fig. 5. 2 Water Chemistry Data worksheet

Raw data is available on this worksheet, the BMWP and RIVPACS Help file is accessed by clicking the button "BMWP and RIVPACS Help". The Help file is shown here and the can be expanded or modified to suit other issues.

Spreadsheet navigation is facilitated by the presence of navigation buttons in the top-left-corner of each worksheet.

6. Link with other Work Packages

The URBEM project describes WP3 task as collecting and presenting data from the different partners to test the assessment tool devised by HR Wallingford in WP5. WP6 (Implementation and review of new assessment tool) is to assess the relevance of the tool. The tool will be assessed in each case study catchment, using if possible the relevant collected data related to the river rehabilitation scheme taking place in the different river stretches. The testing of the tool will take place after month 24 and it will give an opportunity to see how valuable the current WP3 dataset is. WP11 is the training and dissemination work package for all work packages in URBEM. The interactive spreadsheet could be integrated in WP11 to present the dataset to the end-users and the European citizens.

7. Conclusions and Recommendations

The analysis of the collected data shows the difficulty to harmonise data collection between the different partners. This is because:

- The different URBEM River rehabilitation schemes are not at the same stage of completion and the impact is a certain disparity between the different case studies dataset. For example the Ouseburn rehabilitation scheme is still in the planning process and some of the work might start only from in 2005. CEMAGREF has started in 2002 ago to collect data for the Chaudanne stream and Wien River monitoring has started in 1999 and will continue until 2005

- Most of the partners were themselves responsible for collecting either a part or the full dataset. For example, CEMAGREF and University of Ljubljana collected themselves the whole dataset; University of Newcastle only collected some social and economic wellbeing indicators and assembled the rest of the dataset from various sources (Environment Agency, Digimap, and Newcastle City Council). This was made possible as the different data could be retrieved from the different government bodies without any cost for the project

- Different research groups with different research interests form the URBEM consortium and this multi-disciplinarity aspect can be a source of problem during a data collection exercise such as WP3. Each partner has to collect data in one or several research areas unfamiliar to them. For example, University Of Ljubljana found it difficult to collect the socio-economic and well-being attributes data as opposed to the technical University of Dresden, which did an excellent job in this section as this type of data is part of their research areas

- The different dataset were ranked differently and a common analytic method of the different datasets and their ranking was not entirely possible as the datasets were different in many aspects. For example for the physico-chemical parameters the number of samples was inadequate for a thorough analysis. The other indicators (socio-economic and well-being indicators, hydromorphological indicators) are more complicated to compare as each river rehabilitation sites have very different issues (non-natural bed, sewage effluent, etc) and the robustness of the dataset. The assessment method followed the REFCOND guidelines and shows the difficulty of harmonizing data collection when several European partners are involved

- The data collection started at the beginning of the project, 24 months ago, and as the assessment tool was only presented in its draft form in May 2004, six months before WP3 conclusion, thus there was a very short amount of time to ascertain how the WP3 data will be used in WP5 and WP6. At the Ljubljana meeting, University Of Ljubljana hosted a workshop on WP6 and the last year of the project is dedicated to the testing of the whole URBEM package. The assessment of the tool within the different case study sites should help to establish the links between the different work packages and hopefully draw attention to the intrinsic problems generated by a new methodology

- WP3 objective was to collect the relevant information from the selected urban watercourses and report on the monitoring work carried out. The collected data is presented in a spreadsheet and a simple ranking system a quick evaluation of the different dataset provided by the partners. From this existing spreadsheet, an Access relational database is to be created. This database would be used as a base for a nested framework approach which seems to be more suitable for the whole URBEM framework

- A nested framework approach (different spatial scales available (catchment, river stretch, habitat) would provide a view on the current catchment and its issues. The current database, the future relational database and the interactive spreadsheet will support the framework. The MS Access database will extract from the current Excel database the data and redistribute it at different spatial scales (catchment, river stretch). Common catchment characteristics (catchment area, annual average rainfall, etc) and river stretch (river stretch length, water quality, etc) could be extracted from the current dataset. Additional data can be inserted later in the existing dataset

- The current dataset is available on URBEM ftp site, case study partners can access it and submit to UNEW any necessary amendment or changes. The current version of the dataset is not regarded as the final version as the application of WP6 will certainly trigger a new perception of how to present the current data to the end user partners.

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8. Appendices

The appendices describe the different data collection methodologies used by the five URBEM partners involved in WP3.

8.1 Chaudanne

Water analysis

Surface water was collected in 2 L jars and hyporheic water was picked out from the Bou-Rouch pumpings in 2 L jars, kept to 4°C during the travel to laboratory.

Parameters	standard method
pH	NF T90-008
Conductivity	EN ISO 27888
COD	NF T90-101
Oxydability	ISO 8467
MES	EN T90-105.2
DOC	NT 90-102
MVS	NF T90-105
TAC (HCO_3^-)	NF T90-036
Cl^-	ISO 9297
Na^+	NF T 90-019
NH_4^+ (N)	ISO 11732
Nk (N)	EN 25 663
NO_2^- (N)	ISO 13395
NO_3^- (N)	ISO 13395
P_T (P)	EN 1189
PO_4^{3-} (P)	EN 1189
Cd	ISO 5961
Cr	EN 1233
Cu	FD T 90 112
Pb	FD T 90 112 ou FD T 90 119
Zn	FD T 90 112

Sediment analysis

The sediment samples has been kept to 4°C during the travel to laboratory, then sieved at 2 mm, lyophilised and grind in an automatic grinder..

Metal quantification

Parameters	standard method
Cd	ISO 5961
Cr	EN 1233
Cu	FD T 90 112
Pb	FD T 90 112 ou FD T 90 119
Zn	FD T 90 112

Quantification of the PAH in sediments (XPX 33-012)

HAP are determined by High Pressure Liquid Chromatography (HPLC) on C_{18} (octanedecylsilane) column with water/acetonitrile as eluant and fluorimetric and ultraviolet detections (ISO/CD 17993) after extraction on around exactly 1 g of sediment + 1 g of copper powder, on soxhlet instrument and heptane/acetone 1/1 during 6 hours. After the extraction, evaporation with a rotary evaporator and under a nitrogen flux, in taking care to stop before dryness. Purification on a column with silica gel with 9 mL of heptane/toluene 2/1. Evaporation to 1 mL.

Material and methods (Chaudanne study site, France): biological data.

Michel LAFONT, Anne VIVIER, Jean-Claude CAMUS

Field methods

The benthic and hyporheic oligochaete and crustacean assemblages were sampled at the same locations at four sites. Benthic sediments were collected using a Surber-type net (400 cm^2 aperture; net mesh-size: 0.160 mm). In the hyporheic system, 10 litres of material (sediments and interstitial water) were pumped at –20 to –30 cm depths by using a Bou-Rouch pump (Bou & Rouch 1967). Three replicates were collected (a sample each 30 feet). The benthic replicates were pooled together in the same glass jar at each occasion. The hyporheic replicates were kept separately. Samples were preserved in the field with 4% formaldehyde.

Laboratory methods

In the laboratory, the mineral particles (stones, gravel, sand) were separated from the organic fraction (organic fragments and invertebrates) by decanting. The benthic and hyporheic samples were washed through a 0.160 mm sieve. The residue from the sieving of each sample was poured into a squared sub-sampling box. A total of 100 oligochaete and 100 crustacean specimens were sorted by hand under a binocular microscope, from sub-samples taken randomly with a dropping tube from the squares of the sub-sampling box. Worm specimens were mounted on slides with a mixture of lactic acid and glycerin (50% glycerin, 50% lactic acid), covered by a cover-glass, and identified to species level when possible. Crustacean specimens were mounted on slides with a drop of glycerin, covered by a cover-glass, and also identified to species level when possible. Hyporheic samples with invertebrate densities lesser than 10 specimens•30 l^{-1} were not considered. The mean value of the 8 following variables, calculated from the three replicates.

Four biological variables were considered: the number of oligochaete species and their densities (NOSP and DOLA, respectively), the number of crustacean species and their densities (NCSP and DCRA, respectively). Species richness and densities were converted into $Log_{10}(n + 1)$ for normality. Four "functional traits" (FTrs) were also considered (Table 1). The FTrs are defined as the common information derived from the ecological knowledge of indicator oligochaete species, and allowing to assess the ecological functioning of the functional units "surface coarse sediments" and "hyporheic system" (FU3 & 4) (Lafont, 2001; Lafont et al. 2000).

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Biological FTrs	**Oligochaete species characterizing each FTr**
FTr1 “Permeability”	Characterized in a given sample by the percentages of oligochaete species which indicate active hydric exchanges between surface and ground water (Lafont et al. 1992, 1996): *Trichodrilus strandi, Stylodrilus heringianus, S. parvus, Rhyacodrilus ardierae, R. coccineus, R. falciformis, R. subterraneus, Haber speciosus, Pristina aequiseta, Pristinella jenkinae, P. osborni, Cernosvitoviella atrata, Achaeta vesiculata, Marionina argentea, Haplotaxis gordioides*
FTr2 “Intolerance” (to water pollution)	Characterized in a given sample by the percentages of oligochaete species which are intolerant to water pollution (Lafont 1989, Lafont et al. 1996, Lafont & Juget 1993): *R. ardierae, R. falciformis, R. subterraneus, C. atrata, A. vesiculata, M. argentea, Eiseniella tetraedra*
FTr3 “Tolerance “ (to water pollution)	Characterized in a given sample by the percentages of oligochaete species which are tolerant to water pollution (op. cited): *Nais elinguis, P jenkinae, Dero digitata, Marionina riparia*
FTr4 “Sludge effect”	Characterized in a given sample by the percentages of oligochaete taxa which are indicators of the presence of polluted sludge in coarse substrata (Brinkhurst 1965, Lafont 1989, Lafont et al. 1996): Immatures of Tubificidae with and without hair setae, *Tubifex ignotus, T. tubifex, Limnodrilus hoffmeisteri, Bothrioneurum* sp, *Lumbricillus* spp.

Table 1. Characterization of the functional traits (FTrs) by oligochaete species assemblages in surface coarse sediments and hyporheic system; all the above-mentioned species have been found in surveys of the stream Chaudanne.

9.1 Ljubljana

STUDY AREA DESCRIPTION

The Gradascica River basin spreads in the transitional area from the Dinaric into Alpine region in the central part of Slovenia. The headwater section flows through the varied mountain relief of the Dolomites, and is carved with numerous ravines and valleys (Fig. 1). The Gradascica River basin comprises an area of 154.4 km^2, which reaches far into the Polhov Gradec Mountains.

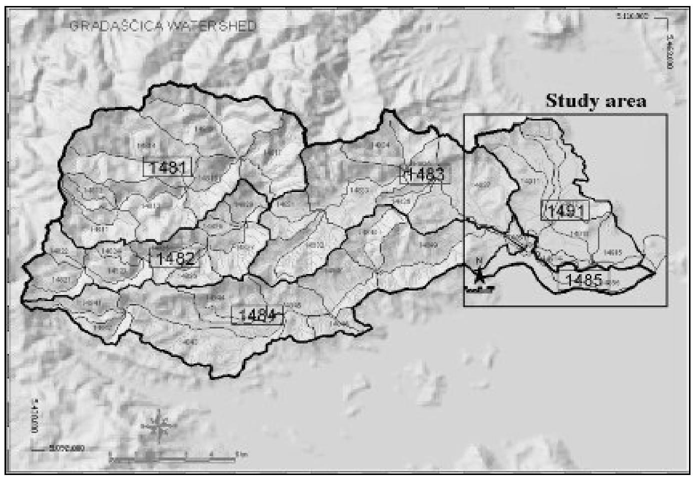

Fig. 1: The Gradascica River watershed.

Steep slopes, fairly high altitudes and abundance of precipitation (average yearly quantity from 1600 to 1700 mm) result in a quick rise in the water level of the Gradascica. The plain area of the Ljubljana basin widens on the eastern part of the watershed. At the Bokalce dam, the Gradascica splits into two water bodies, the Mestna Gradascica and the Mali Graben, which flow into the Ljubljanica River (Fig. 2). The peak discharge of the secular high water wave in the profile above the Bokalce dam is up to 243 m^3/s. The Bokalce dam controls the discharge to Mestna Gradascica stream and only about 10 % of discharge of the Gradascica River diverts to the Mestna Gradascica stream. The Mali Graben carries in total about 90 % of discharge of the Gradascica River.

The study area is a sub-watershed of the water bodies of the Mali Graben, Mestna Gradascica and Glinscica, which is the tributary of the Mestna Gradascica stream. The Mestna Gradascica watershed is situated parallel to the Mali Graben watershed. The area is close to the city centre and is heavily urbanised. The stream was heavily modified and regulated by concrete blocks. The Mestna Gradascica also divides into the upper and lower part related to confluence with the Glinscica. The Glinscica water body divides into the upper Glinscica, tributary Przanec and lower Glinscica (Fig. 2). Yearly precipitation in the study area is 1400 mm.

The former watershed area of the Glinscica stream comprised 16.7 km^2. The runoff within the urban area was determined by the removal of rainfall water by the sewerage system, and thus the orographic barrier failed to coincide with the actual Glinscica drainage area. The total drainage area of the Glinscica up to its outflow into the Mestna Gradascica stream is somewhat larger and comprises 19.3 km^2 of the watershed area, since the precipitation runoff from the area on the north-east part is diverted to the Glinscica watershed area via a storm water system. According to the CORINE database, there are estimated 21 % of urban areas and 26 % of urban green areas that is 12.1 km^2 of the study area.

The land cover of the study area consist of continued and discontinued urban fabric, industrial units and roads; green urban areas, sport and leisure facilities; agricultural areas consist of non-irrigated arable land, pastures, complex cultivation patterns and land, principally occupied by agriculture, with large areas of natural vegetation; and forests include broad-leaved forest, coniferous forest and mixed forest.

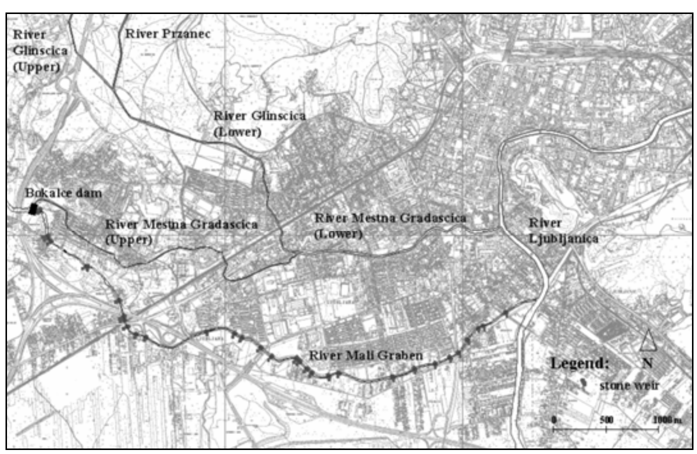

Fig. 2: The urbanized part of the Gradascica River watershed.

3. Ouseburn

EA General Quality Assessment of rivers

Chemistry

The Agency's method for classifying the water quality of rivers and canals is known as the General Quality Assessment scheme (GQA). It is designed to provide an accurate and consistent assessment of the state of water quality and changes in this state over time. The scheme consists of separate windows on water quality. The Chemical GQA describes quality in terms of chemical measurements which detect the most common types of pollution. It allocates one of six grades (A to F) to each stretch of river, using the same, strictly defined procedures, throughout England and Wales. The process is set out below.

· To each sampling site, we assign the stretch of river that the site will characterise. In the main, these sites, and the monitoring, are the same as those used to take decisions on developments that may affect water quality - discharges, abstractions and changes in land use.

· We use only the results from the routine pre-planned sampling programmes with samples analysed by accredited laboratories. To avoid bias we ignore all extra data collected for special surveys or in response to incidents or accidents. The routine programme involves monthly sampling at some 8,000 monitoring points on over 40,000 kilometres of rivers and canals.

· Sites are sampled a minimum of 12 times a year. We use the data collected over three years because this produces 36 samples per site, giving the required precision in making judgements about particular rivers, bearing in mind the cost of monitoring. All the results collected over the three years are included. No extreme data values are excluded.

· The percentiles are calculated from the samples using the method of moments, assuming a normal distribution for dissolved oxygen and lognormal for biochemical oxygen demand (BOD) and ammonia. The estimates of the percentiles are compared with the standards in Table 1. A grade is assigned to each river length according to the worst determinand.

This is the 'face-value' grade.

· All data and results for all rivers are made available to the public.

The grade is defined in Table 1 by standards for biochemical oxygen demand (BOD), ammonia and dissolved oxygen. These determinands are indicators of pollution that apply to all rivers, first because of the widespread risk of pollution from sewage or farms, and second because of the toxicity of ammonia and the requirement for dissolved oxygen for aquatic life, including fish. Table 2 describes the general characteristics of each grade.

Table 1: Standards for the chemical GQA

GQA grade	Dissolved oxygen (% saturation) 10-percentile	Biochemical oxygen demand (mg/l) 90-percentile	Ammonia (mgN/l) 90-percentile
A	80	2.5	0.25
B	70	4	0.6
C	60	6	1.3
D	50	8	2.5
E	20	15	9.0
F	<20	-	-

Table 2: Grades of river quality for the Chemical GQA

Chemical grade		Likely uses and characteristics*
A	Very good	All abstractions Very good salmonid fisheries Cyprinid fisheries Natural ecosystems
B	Good	All abstractions Salmonid fisheries Cyprinid fisheries Ecosystems at or close to natural
C	Fairly good	Potable supply after advanced treatment Other abstractions Good cyprinid fisheries Natural ecosystems, or those corresponding to good cyprinid fisheries
D	Fair	Potable supply after advanced treatment Other abstractions Fair cyprinid fisheries Impacted ecosystems
E	Poor	Low grade abstraction for industry Fish absent or sporadically present, vulnerable to pollution** Impoverished ecosystems**
F	Bad	Very polluted rivers which may cause nuisance Severely restricted ecosystems

*Provided other standards are met

**Where the grade is caused by discharges of organic pollution

3.2 Biology

The biological scheme is based on the macro-invertebrate communities of rivers and canals. Macroinvertebrates are small animals that can be seen with the naked eye. They include insects such as mayflies and caddis-flies, together with snails, shrimps, worms and many others. Macro-invertebrates are the most widely used organisms for biological assessment because they are found in virtually all fresh waters, they do not move far and respond to everything contained in the water, as well as to physical damage to their habitat. They can be affected by pollutants that occur infrequently or in very low concentrations and which may be missed by chemical sampling.

The variety of macro-invertebrates differs from site to site and from river to river even when there is no pollution or physical disturbance. This is because they are affected by the size, slope, altitude and geographical location of the watercourse, the nature of the stream bed, the river flow and the geology of the catchment. Because of these natural differences, it is best to describe biological quality as the difference between the macro-invertebrate community actually found in the river and that which would be expected under natural conditions. We use a computer-based system to predict the macroinvertebrates that would be found if the river was unpolluted and undamaged. The system is called RIVPACS (River Invertebrate Prediction and Classification System) and was devised by the Freshwater Biological Association (later the Institute of Freshwater Ecology and now the Centre for Ecology and Hydrology).

There are about 4,000 species of aquatic macro-invertebrates in the British Isles. To simplify the analysis of the samples and the data we do not identify individual species but only the major types (taxa), mostly at the family taxonomic level. A key piece of information is the number of different taxa. A fall in the number of taxa is a general index of ecological damage, including overall pollution (organic, toxic and physical pollution such as siltation, and damage to habitats or the river channel).

For consistency, we only consider the taxa used in the BMWP (Biological Monitoring Working Party) system (see below) when determining the number of taxa. Some animals are more susceptible to organic pollution than others and the presence of sensitive species is a sign that water quality is good. This fact is taken into account by the BMWP System.

In this, a numerical value has been assigned to about 80 different taxa (known as the BMWP-scoring families) according to their sensitivity to organic pollution. The average of the values for each taxon in a sample, known as ASPT (average score per taxon) is a stable and reliable index of organic pollution. Values lower than expected indicate organic pollution.

The most useful way of summarising the biological data was found to be one that combined the number of taxa and the ASPT. The best quality is indicated by a diverse variety of taxa, especially those that are sensitive to pollution. Poorer quality is indicated by a smaller than expected number of taxa, particularly those that are sensitive to pollution. Organic pollution sometimes encourages an increased abundance of the few taxa that can tolerate it.

RIVPACS is used to predict the number of taxa and the ASPT that would be expected at each site if the environmental quality was good. We combine the results from samples collected in spring and autumn to take account of seasonal variations. Both ASPT and number of taxa in the samples are divided by the equivalent values predicted by RIVPACS so that they are expressed as the proportion of their value when environmental quality is good. These proportional values are called Ecological Quality Indices (EQIs).

An EQI of about 1 indicates that the ASPT or number of taxa in the sample collected from the site was the same as that predicted for the site by RIVPACS. From this we infer that the site is not damaged ecologically and that it is not polluted. Lower values of EQI indicate that the environment is damaged or the river is polluted. Occasionally, we get EQIs greater than 1: these indicate that the site is of better ecological quality than the average for an unpolluted or undamaged site of that type. EQIs enable us to compare the biological quality at different sites and rivers on a common scale, unaffected by the natural differences in the macro-invertebrates that they can support.

Classification

The biological grades are based on the values of the EQIs set out in Table 4. The grade assigned to a site is whichever one is the poorest, based on either EQI ASPT or EQI for the number of taxa.

Table 4: Biological grades

	Grade EQI for ASPT	EQI for number of taxa	Environmental quality
a	1.00	0.85	very good
b	0.90	0.70	good
c	0.77	0.55	fairly good
d	0.65	0.45	fair
e	0.50	0.30	poor
f	-	-	bad

In setting up a system that applies to all types of rivers we started from the fact that it is easy to recognise the best and worst quality. The system represented by Table 4 started out as a consensus of Environment Agency biologists on the optimal, yet simple, way of giving the appropriate grade to rivers recognised as poor or bad. We then drew up a similar consensus for rivers of best quality.

Between the extremes of very good and bad we chose intermediate grades that allow us to detect and report gradual changes so that we can act on deteriorations before they go too far. Although the biology of these intermediate grades will differ from site to site in terms of the actual taxa that are present, the grades will reflect the relative position of the sites on a common scale between the best and worst possible quality.

Grade a - very good

The biology is similar to (or better than) that expected for an average, unpolluted river of this size, type and location. There is a high diversity of families, usually with several species in each. It is rare to find a dominance of any one family.

Grade b - good

The biology shows minor differences from Grade 'a' and falls a little short of that expected for an unpolluted river of this size, type and location. There may be a small reduction in the number of families that are sensitive to pollution, and a moderate increase in the number of individuals in the families that tolerate pollution (like worms and midges). This may indicate the first signs of organic pollution.

Grade c - fairly good

The biology is worse than that expected for an unpolluted river of this size, type and location. Many of the sensitive families are absent or the number of individuals is reduced, and in many cases there is a marked rise in the numbers of individuals in the families that tolerate pollution.

Grade d - fair

The biology shows considerable differences from that expected for an unpolluted river of this size, type and location. Sensitive families are scarce and contain only small numbers of individuals. There may be a range of those families that tolerate pollution and some of these may have high numbers of individuals.

Grade e - poor

The biology is restricted to animals that tolerate pollution with some families dominant in terms of the numbers of individuals. Sensitive families will be rare or absent.

Grade f - bad

The biology is limited to a small number of very tolerant families, often only worms, midge larvae, leeches and the water hog-louse. These may be present in very high numbers but even these may be missing if the pollution is toxic. In the very worst case there may be no life present in the river.

The classification of waters is not precise and there is an average risk of 22% that rivers may be classed wrongly. It is unusual, however, for this error to extend beyond the neighbouring grade.

Whenever a biological grade is calculated, the 'confidence of classification' is also assessed. This is described below.

Sampling

Complete national surveys were carried out in 1990, 1995 and 2002. From 2002 we began to sample one third of sites each year, so that every site is sampled once in three years. The reported results use the most recent data at each sampling site.

A consistent discipline is adopted across the country for sampling and analysis. This includes systems for auditing and controlling the quality of the data.

Each biological site corresponds to a stretch of river also characterised by a chemical site. Although the biological and chemical sites are not always coincident, they are subject to the same water quality, and as far as possible are not separated by tributaries, discharges, weirs or other potential influences on water quality.

Two biological samples are collected, one in spring (March to May) and one in autumn (September to November). Strictly defined protocols are followed to ensure that the data are comparable throughout England and Wales, and compatible with RIVPACS. To take account of natural seasonal variations, the lists of families from samples collected in spring and autumn are pooled for the calculation of ASPT and the number of taxa at each site.

The samples are collected by three-minutes of active sampling with a pond net. At some deep sites where this is not possible, the samples are collected by three to five trawls with a dredge or by air-lift, followed by a one-minute sweep with a pond net. Every sample is supplemented with a one-minute visual search for individual animals living on the water surface or attached to rocks, logs or vegetation.

All the samples are analysed in laboratories. The methods used to wash and sort the samples have been standardised as far as possible.

A scheme of quality control is established in every laboratory, to ensure that an average of no more than two taxa were missed in each sample. This involves re-inspecting 10% of all samples. There is also an independent audit in which 20 samples from each laboratory are re-analysed by biologists from the RIVPACS Team at the Centre for Ecology and Hydrology in Dorset. When introduced, these were the first systematic schemes for measuring and controlling the analytical quality of ecological surveys of this type and size anywhere in the world. Periodical calibration workshops are attended by every biologist involved in GQA surveys to ensure that practices in each laboratory do not diverge from standard. All the procedures are documented in full to provide additional quality assurance.

A common and unavoidable source of error is that a biologist may fail to notice all the taxa collected.

The animals are often difficult to spot amongst the vegetation, gravel, silt or detritus collected with the sample. This error is much more likely than its opposite, of recording a taxon that is not in the sample. This introduces a bias and means that our assessments of biology tend to be pessimistic estimates of the true quality of the river.

Before we started to measure our analytical quality and adopt standardised methods, our biological laboratories had different approaches to controlling the reliability and accuracy of their data, and they achieved different levels of quality. Since 1990, when the new methods were introduced, the quality of the work done by our laboratories has improved. This caused a reduction in the number of missed taxa, which could have led to a spurious indication that the water quality had improved, particularly between 1990 and 1995. However, because we always measure our errors, we are able to take account of this bias. From the 2002 release onwards we have reported all the biological results with a correction made for these known errors. The effect of this is for the historical results to be reported as better quality, and the improvements over time to be smaller than previously reported.

Environmental measurements collected for RIVPACS comprise the width and depth of the stream, the alkalinity of the water and the percentage cover on the river bed of boulders, gravel, sand and silt.

RIVPACS uses annual averages based on measurements taken in spring, summer and autumn. The biological GQA grading is based on RIVPACS predictions used for the 1995 GQA survey, in order to reduce error variations.

Although derived from actual measurements, these predictions may be based on data from a mixture of years so that they represent typical conditions. However, environmental measurements for RIVPACS are collected with every biological sample so that we can check that the measurements on which the predictions are based are still representative. RIVPACS also uses information from maps about the sampling site. This includes the grid reference, the slope of the river, its altitude and the distance of the site from the source of the river.

Nutrients

Introduction

The General Quality Assessment scheme (GQA) is the Agency's national method for classifying water quality in rivers and canals. The scheme provides a way of comparing river quality from one river to another and for looking at changes through time. We assess water quality using in four separate ways: chemistry, biology, nutrients, and aesthetics. This describes the way in which the nutrient assessment is done.

Data collection

Water samples are collected from about 8,000 monitoring sites monthly. These represent over 40,000 kilometres of rivers and canals. To each sampling site, we assign the stretch of river that the site characterises. In the main, these sites are the same as those used to take decisions on developments that may affect water quality, for example, discharges, abstractions and changes in land use.

The samples are analysed for their concentrations of two nutrients: nitrate and phosphate. For phosphorus, total reactive phosphorus is measured using a flow-injection colorimetric method.

Unfiltered samples are used. The method uses ammonium molybdate and potassium antinomyl tartrate, with ascorbic acid as the reducing agent. The results are recorded as measurements of orthophosphate (as mg P/l). Nitrate is recorded as total oxidised nitrogen (mg NO3 /l).

The data collected over three years are used to determine average nutrient concentrations. So the classification for the year 2000 includes the results for

1998 and 1999. We use data from three years (36 samples per site) because this will reduce any variation due to unusual weather conditions. All the results collected over the three years are included. No extreme data values are excluded. We use only the results from routine, pre-planned sampling programmes with samples analysed by accredited laboratories. To avoid bias we ignore all extra data collected for special surveys or in response to pollution incidents.

Classification method

A grade from 1 to 6 is allocated for both phosphate and nitrate. These are not combined into a single nutrients grade. In this respect it differs from the chemical and aesthetic classifications which combine factors into a single grade. This cannot be done for nutrients.

There are no set ‘good’ or ‘bad’ concentrations for nutrients in rivers in the way that we describe chemical and biological quality. Rivers in different parts of the country have naturally different concentrations of nutrients. ‘Very low’ nutrient concentrations, for example, are not necessarily good or bad; the classifications merely states that concentrations in this river are very low relative to other rivers.

Phosphate grades

The table below gives the limit for each phosphate grade, i.e. averages less than 0.02 are graded class 1. The description given uses common terms to distinguish between the classes.

Classification for phosphate	Grade limit (mgP/l) Average	Description
1	<0.02	Very low
2	>0.02 to 0.06	Low
3	>0.06 to 0.1	Moderate
4	>0.1 to 0.2	High
5	>0.2 to 1.0	Very high
6	>1.0	Excessively high

The descriptors used relate to the concentrations in the grades. ‘High’ descriptions are used for all the grades where the average is more than 0.1 mg/l.

This is the concentration is considered indicative of possible existing or future problems of ‘eutrophication’. (This is the term given to the enrichment of water by nutrients, especially compounds of nitrogen and/or phosphorus, causing accelerated growth of algae and higher plant forms to produce an undesirable disturbance to the balance of organisms present in the water and the quality of the water concerned.)

High concentrations of phosphate do not necessarily mean that the river is eutrophic. Other factors have to be taken into account such as the amount and type of algae present, flow rates, and dissolved oxygen concentrations.

Nitrate grades

The table below gives the limits for each grade. For example, grade 2 is assigned to averages between 5 and 10 mg NO3/l. The descriptors use common terms to distinguish between the grades.

Classification for nitrate Grade	Grade limit (mg NO_3/l) Average	Description
1	<5	Very low
2	>5 to 10	Low
3	>10 to 20	Moderately low
4	>20 to30	Moderate
5	>30 to 40	High
6	>40	Very high

The descriptors relate to the nitrate concentrations in each class. ‘High’ concentrations refer to average concentrations above 30 mg/l. This limit very roughly corresponds with a 95 percentile limit of 50 mg/l which is used in the EC Drinking Water Directive and the EC

Nitrate Directive. There is, however, no direct comparison because the methods used to calculate the 95 percentile for the purposes of these Directives are strictly laid down and cannot be estimated from average concentrations over three years.

Interpreting changes over time

This classification scheme uses average concentrations so that marked changes over time can be detected. There are some policies in place to reduce phosphate and nitrate inputs to some rivers but these are very limited in extent. Most of these policies may result in a river changing grade by one class or more, but rarely more. Because of different natural conditions, it is unlikely that many rivers in East Anglia will achieve class 1 and 2; the nutrient concentrations are naturally greater in this part of the country than in the uplands. The aquatic life in rivers reflects the nutrients available and any marked change in nutrients (increase or decrease) can affect the species present.

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3 National Rivers Authority, 1994. *The quality of rivers and canals in England and Wales (1990 to 1992)*. Water Quality Series No. 19. HMSO, London.

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4. Weidigbtach

1. Hydrological regime

- n.a.

2. Channel Morphology

- Measuring during on-site visits
- Calculation of channel slope and bank slope

3. Cross-sectional data

- Measuring during on-site visits

4. Chemistry and biology data

• Assessment within the frame of the "Gewaessergueteprogramm der Landeshauptstadt Dresden, 2001" (Water Quality Program of the State Capital Dresden, 2001)

- Two measurements on each gauging station:

  >2001 dry weather period:

  - Chemical data August 2001
  - Saprobie September 2001)

  >2002 wet weather period, if possible measurements close to a major storm water event

  - Chemical data Feb-June 2002
  - Saprobie March- June 2001

- **Biological data**: Assessment of saprobic level - assessment of macro- and microzoobenthos after **DIN 38410-M2**[4]

▪ Conducting of the sampling procedure accordingly to the "Zeitsammelmethode", method of LFU (1990) [5]

▪ Macrobenthos was determined according to Schmedtje, U. und F. Kohmann (1992)[6]; Macrobenthos abundance was determined according to methodology of LfU (1990)

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[4] DIN-38410-M2, Available in English

[5] LFU Landesanstalt für Umweltschutz Badenwürtenberg (1990) Biologisch-Ökologische Gewässeruntersuchung, Handbuch Wasser 2. Karlsruhe

- Microzoobenthos was determind according to Berger, Foissner and Kohmann (1997) [7] ; Microzoobenthos abundance was determined following the methodology of Berger, Foissner and Kohmann (1997), but without using their correction factor
- According to the acquired data of colonisation the Saprobiten index is calculated as measure for biological water quality, classification after LAWA (1996) and DIN 38410 M2
- If **Saprobic Index** for **macro**-invertebrates has been determined better than water quality class II and statistical requirements for samples **were fullfilled**, then determination of water quality class took place only in consideration of **Index** for **macro**-invertebrates, because according to Berger, Foissner and Kohmann
- (1997/3) consideration of Index for microzoobenthos in water with low pollution results in a overestimation of the pollution
- If Index for macro-invertebrates was better than water quality class II and statistical requirements for samples were not fulfilled, then physical-chemical parameter as PH, LF, O2 content, occurrence of reduction and the appearance of the water body were considered, if then no clear determination of water quality was possible, determination of a water quality class was omitted

[6] Schmedtje, U. und F. Kohmann (1992) Bestimmungsschlüssel für die Saprobier-DIN-Arten Makroorganismen). Informationsbericht des Bayrischen Landesamtes für Wasserwirtschaft 2/88. München
[7] Berger, Foissner and Kohmann (1997) Betstimmung und Ökologie der Mikrosaprobien nach DIN 38410. Gustav Fischer Verlag

• Chemical data: see following table

Methodology/measurement (eng. Av. = in English available)	On-site	laboratory
pH	DIN 38404 C5, electrometrical (eng.av.)	x
Conductivity (uS/cm)	DIN 38404-C8 (new DIN EN 27888 eng.av.)	x
Temperature (deg. C)		x
Turbidity (NTU)		-
BOD	(BOD5) DIN 38409 – H52 (new DIN EN 18992 eng.av.)	x
COD	DIN 38409 H 41/44 (eng.av.)	x
Faecal Coliform Conc.		-
Trash Index		-
Secchi Depth		-
TSS	(DIN) EN 872, gravimetrical	x
O_2 Saturation (%)	DIN 38408-G22, amperometrical (new DIN EN 25814 eng.av.)	x
smell		-
color		-
sediment		-

Methodology/measurement (eng. Av. = in English available)	On-site	laboratory
Carbon Tetrachlori-de (ug/l)	-	
Dichlorom-ethane (ug/l)	-	

1,1-dichloroet-hane (ug/l)	-
1,2-dichloroet-hane (ug/l)	-
1,1,1-trichloroet-hane (ug/l)	-
vinyl chloride (ug/l)	-
1,1-dichloroet-hene (ug/l)	-
1,2-dichloroet-hene (ug/l)	-
Trichloroet-hene (ug/l)	-
Benzene (ug/l)	-
Toluene (ug/l)	-
Xylene (ug/l)	-
Ethylbenz-ene (ug/l)	-
Styrene (ug/l)	-
Monochlor-obenzene (ug/l)	-
1,2-dichlorobe-nzene (ug/l)	-
1,4-dichlorobe-nzene (ug/l)	-
Trichlorob-enzenes (ug/l)	-

TOC (Total organic carbon)	DIN EN 1484 (H3)	x
Dissolved Oxygen (mg/l)	DIN 38408-G22, amperometrical (new DIN EN 25814 eng.av.)	x
Ca (mg/l)		-
Mg (mg/l)		-
Na (mg/l)		-
K (mg/l)		-
Fe (mg/l)		-
Mn (mg/l)		-
Al (mg/l)		-
Cu (mg/l)		-
Zn (mg/l)		-
Pb (mg/l)		-
Cd (mg/l)		-
As (mg/l)		-
Cr (mg/l)		-
F (mg/l)		-
Hg (mg/l)		-
Se (mg/l)		-
B (mg/l)		-
SO4 (mg/l)		-
Cl (mg/l)	DIN EN ISO 10304-2	x
NO3 (mg/l)	DIN EN ISO 10304-2	x
NO2 (mg/l)	DIN EN 26777 (D10)	x
P (mg/l)	DIN EN 1189 (D11) (Total phosphat ?)	x
PO4 (mg/l)	DIN EN 1189 (D11)	x
NH4 (mg/l)	DIN 38406 – E5 (not in Englis	x

	available)	
Hardness (as CaCO3) (mg/l)		-

5. Social and economic Well being
   - Statistical records: taken from "Statistical Report of Dresden"[8]
   - statistical districts along the brook (sum and average of those along brook)
6. Targetlevels
   - At this point in time the Water Framework Directive is put into law of the German states. Thus the former regulations described below and still applicable, will be replaced in the near future. There have been and are no common quality standards with legal consequences, if targets have not been meet, due to the high investments, which those qualities would require.There were no clear comments made, what the stage of regulations according to the WFD in Saxony is at this point.[9]
   - Biological quality targets
     i. The biological water quality is determined by the assessment of the "Saprobienindex". Class II has been set as common quality target in the "Landesentwicklungsplan Sachsen, 16th of April 1994" (regional policy/strategy plan for Saxony). There are no further target levels determined until now.

[8] Bevölkerung, Arbeit und Soziales 2002, Landeshauptstadt Dresden 2002

[9] Telephone conversation with Mr. Friese 2004/01/29 and Ms. Conradt, 2004/02/12 Sächsisches Landesamt für Umwelt und Geologie

• chemical quality targets

Zielvorgaben für 28 organische Umweltchemikalien in µg/l; es bedeuten:

ZV = Zielvorgaben,
A = aquatische Lebensgemeinschaften,
T = Trinkwasserversorgung,
F = Fischerei; weitere Erläuterungen siehe Text.

Stoff	BLAK QZ (ZV)		
	A	T	F
Dichlormethan	10	1	
Trichlormethan	0,8	1	
Tetrachlormethan	7	3	
1,2-Dichlorethan	2	1	
1,1,1-Trichlorethan	100	1	
Trichlorethen	20	1	
Tetrachlorethen	40	1	
Hexachlorbutadien	0,5	1	
1,4-Dichlorbenzol	10	1	0,02
1,2,3-Trichlorbenzol	8	1	
1,3,5-Trichlorbenzol	20	0,1	
1,2,4-Trichlorbenzol	4	1	
Hexachlorbenzol	0,01	0,1	0,001 1)
Nitrobenzol	0,1	10	
1-Chlor-2-nitrobenzol	10	1	
1-Chlor-4-nitrobenzol	30	1	
1,2-Dichlor-3-nitrobenzol	20	1	
1,2-Dichlor-4-nitrobenzol	20	1	
1,4-Dichlor-2-nitrobenzol	20	1	
2-Nitrotoluol	50	10	
3-Nitrotoluol	50	10	
4-Nitrotoluol	70	10	
4-Chlor-2-nitrotoluol	20	1	
2-Chlor-4-nitrotoluol	-	1	
2-Chloranilin	3	1	
3-Chloranilin	1	0,1	
4-Chloranilin	0,05	0,1	
3,4-Dichloranilin	0,5	0,1	

1) Umrechnung in eine ZV für Schwebstoff: 40 µg/kg HCB im Schwebstoff

Zielvorgaben für Schwermetalle in mg/kg (Schwebstoff) bzw. µg/l (Wasser);

es bedeuten:
ZV = Zielvorgaben,
QZ = Qualitätsziele,
A = aquatische Lebensgemeinschaften,
S = Schwebstoffe und Sedimente,
T = Trinkwasserversorgung,
F = Fischerei,
B = Bewässerung landwirtschaftlich genutzter Flächen; weitere Erläuterur gen siehe Text.

Konzentrationen im Schwebstoff (mg/kg)

STOFF	BLAK QZ (ZV)	
	A	S
Blei	100	100
Cadmium	1,2	1,5
Chrom	320	100
Kupfer	80	60
Nickel	120	50
Quecksilber	0,8	1
Zink	400	200

Konzentrationen im Wasser (µg/l)

STOFF	BLAK QZ (ZV)			
	T	F	B	A*
Blei	50	5	50	3,4
Cadmium	1	1	5	0,072
Chrom	50	--	50	10
Kupfer	20	--	50	4
Nickel	50	--	50	4,4
Quecksilber	0,5	0,1	1	0,04
Zink	500	--	1000	14

* Umrechnung aus Schwebstoffdaten (nur zu Vergleichszwecken)

ii. On German Level (also applicable in Saxony): Recommendations for target levels for pesticides, heavy metals and industrial chemicals from the "Länderarbeits-gemeinschaft Wasser" (Task Force of the States Water Agencies) and Umweltministerkonferenz (Conference of the States Environment Ministers)

iii. In addition: Directive of the State Ministry of Environment and Agriculture Saxony for the purpose of article 7 Directive 76/464/EWG adopted 1st of June 2001 in force for complete Saxony
"Verordnung des Sächsischen Staatsministeriums für Umwelt und Landwirtschaft zur Umsetzung von Artikel 7 der Richtlinie des Rates 76/464/EWG betreffend die Verschmutzung infolge der Ableitung bestimmter gefährlicher Stoffe in die Gewässer der Gemeinschaft vom 1. Juni 2001":

EG-Nr.	Determinand Name	QZ	Unit
2	2-Amino-4-chlorphenol	10	µg/l
3	Anthracen	0,01	µg/l
4	Arsen	40	mg/kg
7	Benzol	10	µg/l
8	Benzidin	0,1	µg/l
9	Benzylchlorid (alpha-Chlortoluol)	10	µg/l
10	Benzylidenchlorid (alpha,alpha-Dichlortoluol)	10	µg/l
11	Biphenyl	1	µg/l
14	Chloralhydrat	10	µg/l
15	Chlordan	0,003	µg/l
16	Chloressigsäure	10	µg/l
17	2-Chloranilin	3	µg/l

18	3-Chloranilin	1	µg/l
19	4-Chloranilin	0,05	µg/l
20	Chlorbenzol	1	µg/l
21	1-Chlor-2,4-dinitrobenzol	5	µg/l
22	2-Chlorethanol	10	µg/l
24	4-Chlor-3-methylphenol	10	µg/l
25	1-Chlornaphthalin	1	µg/l
26	Chlornaphthaline (technische Mischung)	0,01	µg/l
27	4-Chlor-2-nitroanilin	3	µg/l
28	1-Chlor-2-nitrobenzol	10	µg/l
29	1-Chlor-3-nitrobenzol	1	µg/l
30	1-Chlor-4-nitrobenzol	10	µg/l
31	4-Chlor-2-nitrotoluol	10	µg/l
(32)	2-Chlor-4-Nitrotoluol	1	µg/l
(32)	2-Chlor-6-Nitrotoluol	1	µg/l
(32)	3-Chlor-4-Nitrotoluol	1	µg/l
(32)	4-Chlor-3-Nitrotoluol	1	µg/l
(32)	5-Chlor-2-Nitrotoluol	1	µg/l
33	2-Chlorphenol	10	µg/l
34	3-Chlorphenol	10	µg/l
35	4-Chlorphenol	10	µg/l
36	Chloropren (2-Chlorbuta-1,3-dien)	10	µg/l
37	3-Chloropropen (Allylchlorid)	10	µg/l
38	2-Chlortoluol	1	µg/l
39	3-Chlortoluol	10	µg/l
40	4-Chlortoluol	1	µg/l
41	2-Chlor-p-toluidin	10	µg/l
(42)	3-Chlor-o-Toluidin	10	µg/l
(42)	3-Chlor-p-Toluidin	10	µg/l
(42)	5-Chlor-o-Toluidin	10	µg/l
43	Coumaphos	0,07	µg/l

44	Cyanurchlorid (2,4,6-Trichlor-1,3,5-triazin)	0,1	µg/l
45	2,4-D	0,1	µg/l
(47)	Demeton	0,1	µg/l
(47)	Demeton und Verb.	0,1	µg/l
(47)	Demeton-o	0,1	µg/l
(47)	Demeton-s	0,1	µg/l
(47)	Demeton-s-methyl-sulphon	0,1	µg/l
48	1,2-Dibromethan	2	µg/l
49-51	Dibutylzinn-Kation	100	µg/kg
49-51	Dibutylzinn-Kation	0,01	µg/l
(52)	2,4-&2,5-Dichloranilin	2	µg/l
(52)	2.3-Dichloranilin	1	µg/l
(52)	2.4-Dichloranilin	1	µg/l
(52)	2.5-Dichloranilin	1	µg/l
(52)	2.6-Dichloranilin	1	µg/l
(52)	3.4-Dichloranilin	0,5	µg/l
(52)	3.5-Dichloranilin	1	µg/l
53	1,2-Dichlorbenzol	10	µg/l
54	1,3-Dichlorbenzol	10	µg/l
55	1,4- Dochlorbenzol	10	µg/l
56	Dichlorbenzidine	10	µg/l
57	Dichlordiisopropylether	10	µg/l
58	1,1-Dichlorethan	10	µg/l
60	1,1-Dichlorethylen (Vinylidenchlorid)	10	µg/l
61	1,2-Dichlorethylen	10	µg/l
62	Dichlormethan	10	µg/l
(63)	1.2-Dichlor-3-nitrobenzol	10	µg/l
(63)	1.2-Dichlor-4-nitrobenzol	10	µg/l

(63)	1.3-Dichlor-4-nitrobenzol	10	µg/l
(63)	1.4-Dichlor-2-nitrobenzol	10	µg/l
64	2,4-Dichlorphenol	10	µg/l
65	1,2-Dichlorpropan	10	µg/l
66	1,3-Dichlorpropan-2-ol	10	µg/l
67	1,3-Dichlorpropen	10	µg/l
68	2,3-Dichlorpropen	10	µg/l
69	Dichlorprop	0,1	µg/l
72	Diethylamin	10	µg/l
73	Dimethoat	0,1	µg/l
74	Dimethylamin	10	µg/l
75	Disulfoton	0,004	µg/l
78	Epichlorhydrin	10	µg/l
79	Ethylbenzol	10	µg/l
(82)	Heptachlor	0,1	µg/l
(82)	Heptachlorepoxid	0,1	µg/l
86	Hexachlorethan	10	µg/l
87	Isopropylbenzol	10	µg/l
88	Linuron	0,1	µg/l
90	MCPA	0,1	µg/l
91	Mecoprop	0,1	µg/l
93	Methamidophos	0,1	µg/l
94	Mevinphos	0,0002	µg/l
95	Monolinuron	0,1	µg/l
96	Naphthalin	1	µg/l
97	Omethoat	0,1	µg/l
98	Oxydemeton-methyl	0,1	µg/l
(99)	Benzo-a-pyren	0,01	µg/l
(99)	Benzo-b-fluoranthen	0,025	µg/l
(99)	Benzo-g.h.i-perylen	0,025	µg/l
(99)	Benzo-k-fluoranthen	0,025	µg/l
90	MCPA	0,1	µg/l

91	Mecoprop	0,1	µg/l
93	Methamidophos	0,1	µg/l
94	Mevinphos	0,0002	µg/l
95	Monolinuron	0,1	µg/l
96	Naphthalin	1	µg/l
97	Omethoat	0,1	µg/l
98	Oxydemeton-methyl	0,1	µg/l
(99)	Benzo-a-pyren	0,01	µg/l
(99)	Benzo-b-fluoranthen	0,025	µg/l
(99)	Benzo-g.h.i-perylen	0,025	µg/l
(99)	Benzo-k-fluoranthen	0,025	µg/l
(99)	Fluoranthen	0,025	µg/l
(99)	Indeno-1.2.3-cd-pyren	0,025	µg/l
(101)	PCB-101	20	µg/kg
(101)	PCB-118	20	µg/kg
(101)	PCB-138	20	µg/kg
(101)	PCB-153	20	µg/kg
(101)	PCB-180	20	µg/kg
(101)	PCB-28	20	µg/kg
(101)	PCB-52	20	µg/kg
103	Phoxim	0,008	µg/l
104	Propanil	0,1	µg/l
105	Pyrazon (Chloridazon)	0,1	µg/l
107	2,4,5-T	0,1	µg/l
108	Tetrabutylzinn	40	µg/kg
108	Tetrabutylzinn	0,001	µg/l
109	1,2,4,5-Tetrachlorbenzol	1	µg/l
110	1,1,2,2-Tetrachlorethan	10	µg/l
112	Toluol	10	µg/l
113	Triazophos	0,03	µg/l
114	Tributylphosphat (Phosphorsäuretributylester)	0,1	µg/l

116	Trichlorfon	0,002	µg/l
119	1,1,1-Trichlorethan	10	µg/l
120	1,1,2-Trichlorethan	10	µg/l
(122)	2,4,5-Trichlorphenol	1	µg/l
(122)	2,4,6-Trichlorphenol	1	µg/l
(122)	2.3.4-Trichlorphenol	1	µg/l
(122)	2.3.5-Trichlorphenol	1	µg/l
(122)	2.3.6-Trichlorphenol	1	µg/l
(122)	3.4.5-Trichlorphenol	1	µg/l
123	1,1,2-Trichlortrifluorethan	10	µg/l
128	Vinylchlorid (Chlorethylen)	2	µg/l
(129)	1.2-Dimethylbenzol	10	µg/l
(129)	1.3-Dimethylbenzol	10	µg/l
(129)	1.4-Dimethylbenzol	10	µg/l
132	Bentazon	0,1	µg/l

7. Notice

- DIN Norms for the detailing of methodology are available in English, but each costs between 50 and 70 Euro)
- Translations of the Target Levels Descriptions under chemical quality targets ii and iii can be done, if they are needed for the purpose of WP

5 Wien

Site description – Wien River

The aim of this paper is to give a general information on the river basin, the study site and the completed and projected rehabilitation works. A short description of the available chemical and ecological data follows. As the latter is quite voluminous and we do not have direct access to data bases yet, it seems reasonable to discuss, which information to use for URBEM. The last part describes the rainfall data provided by the Hydrographic Central Office and discharge data.

10. River basin, general description

Wien river basin has a total size of 230 km^2, where the downstream 57 km^2 are located in the densely built area of the city of Vienna. The geographical situation is mapped in Figure 10.1 (BEV, 1999), Figure 10.2 shows the land-use in the river basin.

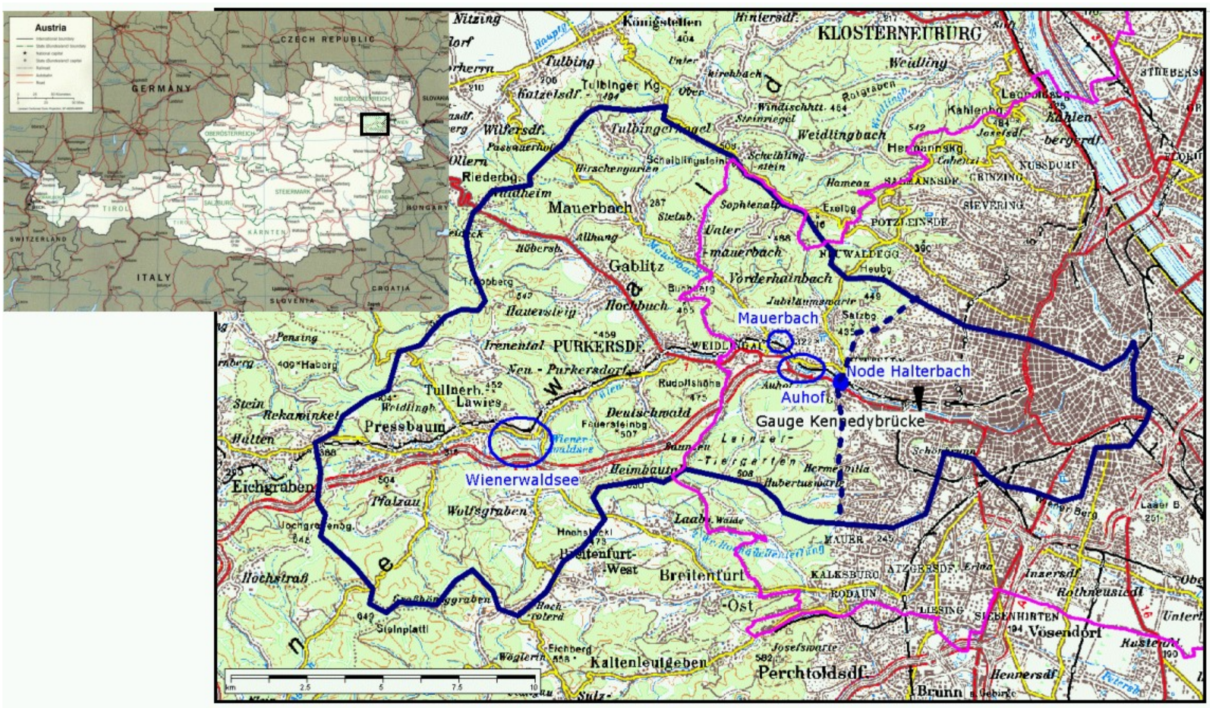
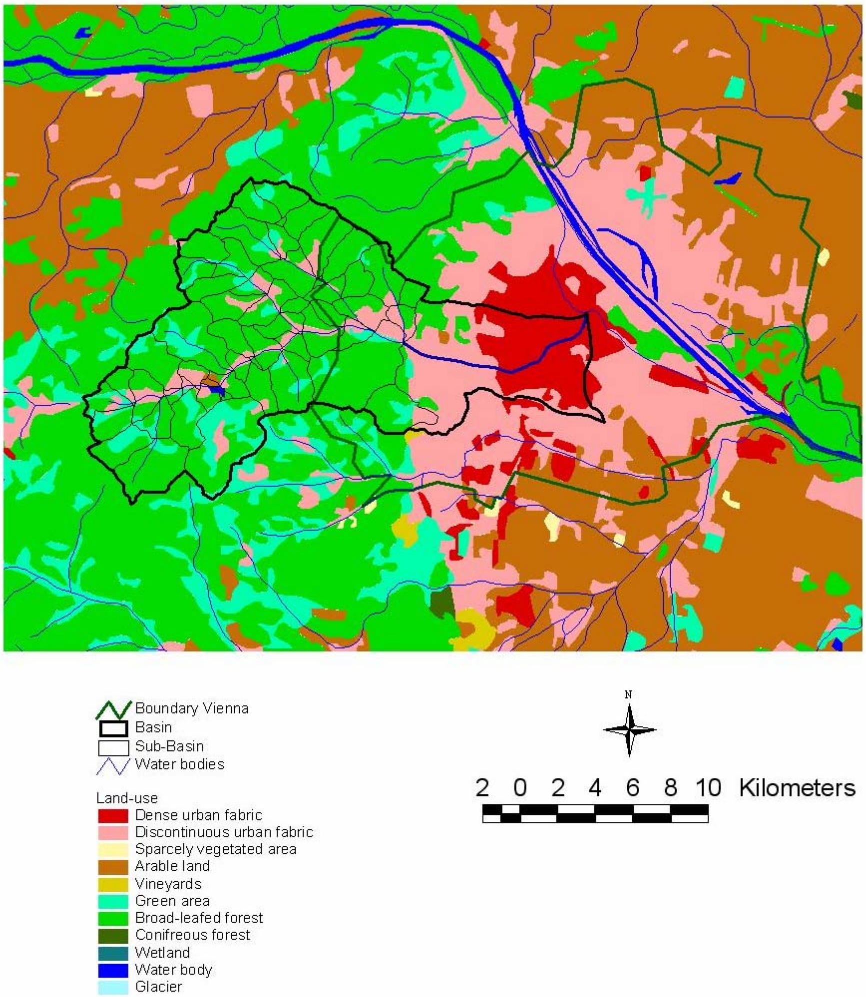


Figure 10.1: Wien River watershed Map: ÖK 200, BEV (1999)

Indicated in Figure 10.1 are:



Watershed with rural (173 km^2) and urban character (57 km^2)	dark blue
Outlet of the rural catchment for rainfall runoff modelling: Node Halterbach	light blue
Flood retention reservoirs: Auhof, Mauerbach and Wienerwaldsee	light blue
Gauge Kennedybrücke in the urban river reach	black
City of Vienna	pink

Rehabilitation works have been conducted in the area of the Auhof and Mauerbach retention schemes, the URBEM activities focus on Wien River at the Auhof site.

Figure 10.2: CORINE land use on Wien River basin

The mean annual precipitation of the 1961 – 1990 series ranges from 790 mm in the western watershed to 530 mm in the region of the mouth (HAÖ, 2003). Since the past, floods have been of major concern and much effort has been put into flood protection. Design storm values of 84 and 118 mm in 6 hours are used for modelling a 100 and a 1.000-year storm event (Neukirchen, 1995).

Although the forests in the rural catchment are protected, urbanisation was going on in the last decades. This is one reason for upgrading the flood protection reservoirs.

Figure 10.3: Scene from the rural Wien River Basin with ongoing urbanisation (MA 45, 1996)

The main aim of the rehabilitation project is to reduce flood hazards in the urban river reach. From a hydrological viewpoint, flood hazards at Wien River are critical due to the large paving ratio in wide parts of the catchment, small geological infiltration capacity, quick rising of flood discharges and little natural retention.

Table 10.1 shows the design discharge quantities downstream the rehabilitated site at the entrance of the urban river reach (Node Halterbach) at km 12.05 from mouth (corresponding to km 21.85 from the source). The Auhof study site is located at km 18.8 to 21.6 from the source. The design aim is to reduce the 1.000-year event to 380 m^3/s, which includes additional 10% safety margin. Compared are three constructional and operational states of the reservoir system:

HQ	Without any retention (natural state)	Before reservoir upgrading	After completed upgrading
1	44	43	43
10	122	120	119
30	184	180	180

100	278	197	226
1000	477	434	340
5000	579	518	478

Table 10.1: Design discharge quantities at the city entrance, node Halterbach (Neukirchen, 1995)

The design goals are achieved by actively operating the retention schemes Auhof, Mauerbach and Wienerwaldsee. The current flood protection system in the Wien River basin (September 2003) consists of the completely upgraded Auhof and Mauerbach scheme and the 12 km canalised urban river. The re-construction of both reservoir schemes serves also ecological and recreational purposes.

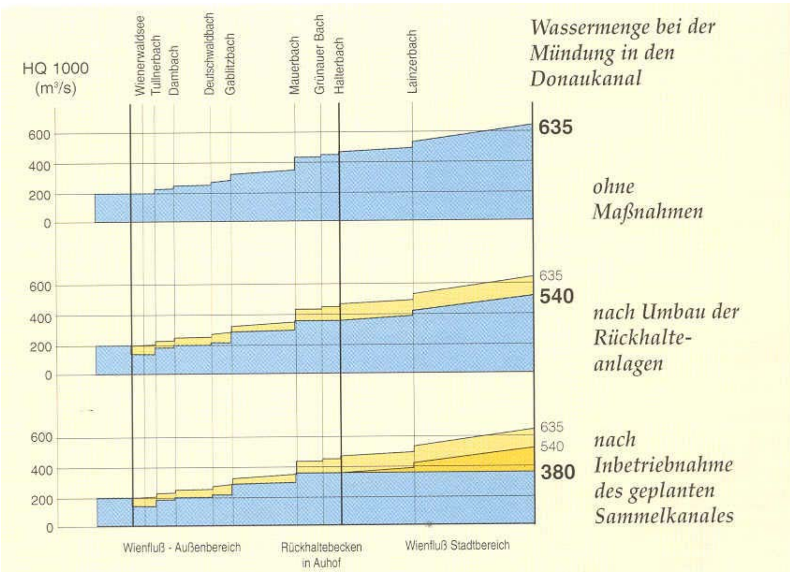
Both, the flood control basins and the urban river reaches were originally engineered from 1895 to 1902. Beside remediation efforts, the urban river is mainly in the constructed state of 1900. According to a critical analysis in the eighties, the retention basin performance was found insufficient for adequate protection requirements. Very large hydrograph peaks like the generated 100 and 1.000 year events pass the flood control basins without considerable reduction of the flood peak (IWHW, 1988). This was due to an insufficient storage volume and control capacity, causing premature basin filling of the Auhof reservoirs by tributaries of the adjacent hills and by the increasing branch of the Wien River hydrograph.

An interdisciplinary study (e.g. in Bauer, 1993) combined ecological and technical issues on reconstructing, extending and adaptively controlling the flood protection works and further proposes a large urban storm water bypass channel below the current river bed. Urban storm water discharges can reach up to 200 m^3/s at the mouth of Wien River in extreme cases (Bauer, 1993; MA 45, 1996). This project aims on reducing the 1.000-year design flood of the rural river basin from its natural value of 475 to 380 m^3/s. The entire urban storm water will be conveyed in a bypass channel, further a forecast-based runoff model for reservoir control will be installed and the retention schemes shall be adapted.

The re-design of the reservoirs is based on hydrologic simulations with a rainfall-runoff model, which was calibrated by the May and August 1991 storms. Future work will focus on the real time control system and the completion of the early warning and reservoir operation system.

The effect of upgrading the protection system from no retention effect to full operation of all 3 reservoir schemes on the 1.000-year design flood peak is demonstrated in the upper and middle hydrologic profile from Wienerwaldsee reservoir to the mouth in Figure 10.4. The remaining discharge in Wien River in m^3/s is coloured blue. The lower profile exhibits the influence of the urban storm water bypass channel.

Wienerwaldsee is an artificial reservoir with a 13,5 m high barrage, it was constructed in 1894 for drinking water provision of demand peaks and emergencies of up to 24.000 m^3 per day (Bauer, 1993). For adapting this



basin to serve flood control, an extension of the barrage and an expansion of control capacity were planned. These works have not been started until 2003. Other drinking water sources will take over its capacity in 2005, and the further utilisation of Wienerwaldsee is not clear. The options of selling the basin to the adjacent Lower Austrian communities or using the basin purely for flood protection purposes are broadly discussed (Kurier, 2002).

Figure 10.4: Hydrological profile of the 1.000-year design peak discharge (MA 45, 1996)

Detailed description of structural and operational basin states are found in Bauer (1993), MA 45 (1996) and Neukirchen (1995; 1996; 1997).

Retention Basin	Flood storage volume [m3]	
	Neukirchen (1997)	Neukirchen (2001)
Auhof	690.200	720.000
Mauerbach 1 + 2	360.000	160.000
Wienerwaldsee	520.000	630.000
Total	Approx. 1,600.000	1,510.000

Table 10.2: Projected retention basin storage capacity along Wien River

10.1 Background on flood hydrology

The maximum discharge on Wien River was estimated for the 18th May, 1851 event with 600 m^3/s at the mouth (Bauer, 1993). Some larger events in the 20th century were estimated at the gauge Kennedybrücke at km 7.65.

Peak discharge [m3/s]	Return Period [a]	Date	Reference
472	70	April 1951	Bauer (1993)
374	23	July 1975	Neukirchen (1997)
374	30-35	July 1975	Bauer (1993)
138	20-25	May 1991	Bauer (1993)
317		7. July 1997	Neukirchen (1997), according to rating curve
285	< 50	7. July 1997	Neukirchen (1997), adjusted
193		7. July 1997	HZB (1999)
125		21. May 1999	HZB (1999)

Table 10.3: Estimates of larger peak discharges at gauge Kennedybrücke, km 7.65

Water surfaces are recorded since 1904 and discharges since 1981. The catchment comprises 199.4 km^2, the mean annual flow from 1981 to 1999 is 1.16 m^3/s (HZB, 1999). The groundwater interactions are not significant.

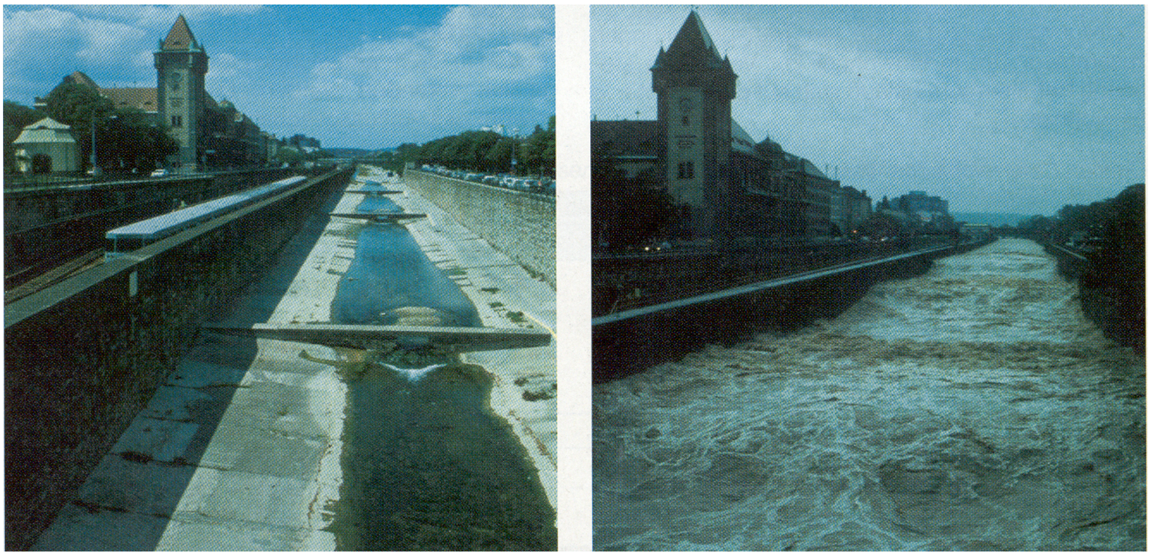


Figure 10.5: Wien river at km 8 during normal flow conditions and during the 1975 flood (Source: Gewässerschutzbericht 2002, BUMLFW)

For the recent improvement of the Wien River flood protection system, which started in 1995, catchment models considering for rainfall-runoff, routing and storage processes provide flood hydrographs entering the urban river reach. The urban storm water runoff is estimated and added along the river. It is assumed that the reoccurrence periods of rainfall and discharge are equal. Catchment models were established by Neukirchen (1985) with a simplified flood control basin performance estimation, IWHW (1988) included a hydrologic retention basin model and Neukirchen (1995) established a rainfall-runoff model as a basis for the projected real time control system. This model was calibrated by two flood events of 1991. The largest peak discharge and volume at the city’s entrance were calculated for the six hours storm.

10.2 Historic development

In the middle ages, Wien River comprised several ponds in today's central district, water was diverted to mills since the 13th century. Trade and industry was located close to the river, using water and disposing sewage: Mills, tanneries, dye works, laundries and a brewery. Wien River and its tributaries were used for waste disposal since the roman epoch. Floods occurred several times, inundating districts and historic buildings. Before the February 1830 flood, caused by a River Danube ice jam and the succeeding cholera epidemic claiming 2000 lives, 90 km of sewers existed. As a consequence, creeks were widely canalised (until the 1980ies). The left and right Wien River collectors still used today were constructed 1831 - 1890. Before the regulation, Wien River was an up to 285 m wide furcating water body with several confluences and alluvial forests. In 1895 the construction of uncontrolled reservoirs and the bypass channel has begun (until 1902), the urban river was regulated and partly covered in 1895 - 1915. In the 19th and 20th century, urbanisation of suburbs took place and the river valley became more important as a rail and road transportation route.

10.3 River basin characteristics

Abiotic characteristics according to WFD, Annex II, System A and B are summarized in Wimmer (2000):

River region	Eastern Danube	
Stream order	5	
Catchment area class	2	
Catchment area	229.5	km^2
Altitude class at the mouth	1	< 200 m.a.s.l
Altitude class at of 75% of the area	2	200 – 500 m.a.s.l
Region	Alps (North-alps, flysch & sandstone foothills of alps)	
Basic water body type	Water body of flysch & sandstone foothills of alps	
Ecoregion	4 (Alps) & 11 (Hungarian planes)	
Coarse geology	Flysch & Helvetikum	
Stream gauge	Kennedybrücke, 199.4 km^2 basin area	
Mean flow (HZB, 1990)	1.07	m^3/s
Flow regime	Konplex: Pluvio-Nival (PLN), winter-intensive	

Table 10.4: Abiotic characteristics of Wien River basin

Flood protection and urbanisation are the main pressures and uses of the river basin. Physical river alterations are described by Konecny (2002):

Change in river profile

- Disruption of the river continuum
- Disruption of the sediment transport
- Canalisations, longitudinal straightening
- Bank reinforcement
- Detached ox-bow lakes, wetlands
- Change in flow regime
- Reduced flow in the river bed

The main effects of hydro-morphological changes can be summarized (Konecny, 2002):

- Reduced fluvial dynamics
- Reduced longitudinal and lateral dynamics
- Large deviations from a type-specific reference condition

11. Study site and rehabilitation works

Since the 1990 novella of the Austrian water law (Wasserrechtsgesetz WRG §105(1) lit.m), the maintenance and advancement of ecological integrity is public interest. This applies also to flood protection.

The rehabilitation works are part of the integrated river basin plan for flood protection, improved ecological situation and rehabilitation.

1) The aim of contemporary flood protection and improved water quality in the urban reach shall be reached by two measures: The first step is the technical rehabilitation of the structural substance and functionality and the capacity extension of the flood control reservoirs, which exist mainly since 1900. This measure comprises the increase of retention-basin wall crests and partially excavations, as well as the installation of reservoir control-units that are operated automatically by a real-time control system. The design goal is to reduce the 1000-year design flood to a flow magnitude, which is considered as not harmful in the urban river reach. Most vulnerable in the urban river reach is the subway line located partly in open sections in the right river bank.

The second step is the construction of a bypass channel for combined urban storm water in and under the existing riverbed. The riverbed itself shall be reconstructed for recreational and soft-traffic purposes with landscape-architectural and bio-engineering measures currently assessed and optimised at the test-flume in the flood bypass channel of the Auhof site. The urban river shall provide a water body in a green area with public access by a parallel bike lane and pedestrian way. The combined urban storm water bypass channel shall collect and store the overspilling urban runoff which is currently overfalling into the Wien River and release it slowly to the purification plant. A current number of up to 200 overflows per year is estimated in Bauer (1993). The canalised urban tributaries shall be disconnected from the combined storm water system.

2) The general target of ecologically oriented measures taken at the Wien River is an increase in the diversity and dynamics of numerous physical, river-morphological, hydrological and biological processes. The reference conditions of the ecological river vision concept on Wien River is deduced from historic sources: The river was a dynamic system with a more or less constantly flowing main branch and several partly well linked side arms, which were stocked with riparian vegetation. Floods often led to substrate shifts, creating new structures and pioneer sites, which could be populated by specialised species.

The area represents the largest wetland-biotope in the west of Vienna. The reservoirs are natural conservation areas for forests and meadows.

The dynamics in sediment erosion/deposition processes and the development of variable habitats shall be achieved by converting the flow up to a two-year flood (30m3/s) through the Auhof retention basins. Bio-engineering methods are used for the sparse regulations, further wetlands and biotopes are constructed in the original flood plains, the longitudinal and lateral connectivity is improved.

Particular aims for landscape architecture and ecology are (Neukirchen, 1997):

Ø Revitalisation of the river bed by removing the continuously spliced invert pavement

Ø Removal/reconstruction of all vertical barriers for organisms in the reservoirs and the bypass channel
Ø Re-direction of the main flow paths through the reservoirs according to its original pattern
Ø Decreasing the channel slope and the shear tension by riffles (low sills) of 0.15m
Ø Vegetation typical for the natural habitat & extensive use of bio-engineering measures

Ø Pedestrian ways and bike lanes at the bypass channel, construction of foot-bridges

The initiating reason for the project was a required improvement of flood protection for the downstream urban river reach and demands by the Austrian water law for ecological integrity. Besides, recreational and urban planning issues were considered. Test sites were constructed to serve the development of bio-engineering regulation and river bed stabilisation measures, which are planned for the urban reach and for a scale model of the projected cross section.

Auhof flood storage schemes consist of an upstream basin (reservoir 2) distributing the discharge into the bypass channel or the storage cascade consisting of five basins (reservoir 3 to 7). During upgrading works, completed in 2001, the weir crests were partly heightened, hydraulic steel structures were upgraded for adaptive control purposes. The landscape of the basins was re-designed under an ecological viewpoint. The flow dynamics is re-established by converting the new river bed and discharges up to 30 m^3/s (2-year event) through the reservoir cascade with a widths up to 200 meters.
Before upgrading, the river was flowing through the bypass channel and during large floods, the reservoir were filling from Wien River discharge starts at 150 m^3/s (HQ_{10}), after the improvement works it will start at 240 m3/s (HQ100) from Wien River (corresponding to 320 m3/s at the city entrance).

Mauerbach basins consist of a distribution basin and one storage basin (reservoir 1). Similar changes like in Auhof were also conducted at Mauerbach reservoir, they were completed in 1998.
The length of the rehabilitated Wien River section is approx. 2.7 km, located between river station km 18.84 to km 21.58 (from the source corresponding to km 15.06 to km 12.32 from mouth; numbers from Neukirchen, 1997). The entire area of Auhof and Mauerbach reservoirs and test flume at the bypass channel amounts to 37 hectares, the Auhof site is 30 hectares (MA 45, 1996).
Parallel to the main construction works, an ecological monitoring program was performed during the 1999 to 2001 period. The monitoring activities will be completed by surveys in 2005. The average discharge of Wien river during the 1999 – 2001 investigations was 0.49 +/- 0.63 m^3/s (Hein, 2002);

Figure 11.1: Auhof and Mauerbach retention schemes (MA 45, 1996)

The entire construction period was 1995 to 2003, where the main work at the Auhof scheme took part from Oct. 1997 - Dec. 2001. The planning process can be dated from May, 1989 to December 1998. The first parts of the real time control system were established in 1995 it shall be completed by Dec. 2004, the test flume was built in 1996 and repaired after heavy flood damage in 1997. The rehabilitation of Mauerbach scheme was conducted between Nov. 1995 and June 1998.

The reconstruction of nature-like channels is providing an initial condition for natural dynamics and succession in the reservoirs. As natural succession processes from up and downstream and connections with the mouth are intended, artificial plantings are kept to a minimum.

11.1 Measures concerning the reservoirs

Increased height of weir crest
Installation of fully controllable gates
Operation of gates according to ecological demands during normal conditions
Opening of weirs (Structural barriers)
Rehabilitation of thread
Increased variance of widths
Increased variance of depths
Stabilisation of islands by netting willows (Weidenflechtzaun)
Dynamics due to opened weirs
Bed load transport

11.2 Measures concerning the watercourse

re-opening of paved invert
Inserting river bed substratum
Replacing sills by riffles (ramps)
Bed stabilisation by boulders, arrangement of various habitats
Variability of flow velocity
Construction of compound sills
Variance of depths
Variance of widths
Construction of islands
Extension of the shore-line
Variability of river bank slopes
Water-land transition zones

Bio-engineering bank-structures

Bed-load dynamics

Shadowing

11.3 Bypass channel

Test flume (Vollsinger, 2002), approx. 170 m length

Willow brush mattress, width = 4,5 m (Weidenspreitlage)

Branch layer, widths = 4,2 m (Astpackung)

Fascine layer, widths = 4,0 m (Faschinenreihe)

Channel further downstream

Bed protection with 0.8 meter boulders, interspace filling (size 10-20cm), covered with a 10-20 cm layer of sandy gravel.

The mean natural gradient (max. 1.5%o) was achieved by 10-15 cm riffles/sills in the distance of 7 – 10 m: Type1: Invert strap (Sohlgurt) made of rocks, depth: 2.3m, widths: 1.2m, with pools 0.7 - 0.9 m depths; type 2: Vertical piles, Ø 0.2 m with horizontal wooden trusses, pools protected with 0.8 m rock layer; type 3: Inclined grid, length: 4 m, Ø 0.2 m spars with pool, both protected by a 0.8 m rock layer (Source: www.porr.at/berichte/na131/wienfluss.htm)

11.4 Measures concerning accessibility, recreation

Direct access to the rehabilitated site is provided by 1 pedestrian ramp to each reservoir and bike lanes and trails approaching to the site.

A grill-place in was installed upstream reservoir 2

Visitors and guided tours of school classes, interested citizens, local population are using the site, as well as university courses

11.5 Measures for birds

20 breeding boxes, provided by a private association were placed in reservoir 4, mainly for public relation and nature observation and perception: Breeding boxes for *Cinculus Cinculus* (Water ouzel) on two sites; 3 breeding walls for *Alceod Atthis* (Water king-fisher): Type A:

Gabions with artificial breeding pipes; Type B: Wall of sand, loam and lime with preliminary pond

11.6 Measures concerning public information

About 10 years of information campaigning with presentations, discussions, radio spots…

Folder, brochure and CD for public information on the projected river concept

Videos on ecological evaluation and the soil bio-engineering test flume

Journal edition on activities

Information boards on the rehabilitation project installed at the site

Short project overview by Municipal Hydraulic Engineering Department: http://www.wien.gv.at/wasserbau/wienflus.htm. Many other internet sites inform about the project. Several documentation spots in radio, TV

11.7 Ongoing programs

Ongoing programs and projects within the basin cover a stepwise construction of the urban combined storm water bypass channel in/parallel to Wien River bed in downstream urban reaches. Further, the rehabilitation of a 100m river reach approx. 1km downstream the Auhof schemes is currently constructed. The ongoing improvement of the flood construction system regard the completion of the real time control system. The former projected adaptation of Wienerwaldsee reservoir for active flood control is currently discussed again.

12. Chemical and ecological data

Data from the rehabilitated sites on Wien River and Mauerbach is available from ecological monitoring programs, chemical analysis and some diploma thesis. The ecological monitoring program was conducted from 1999 – 2001 to assess the impacts of revitalization works (mainly 1995 – 2003) on several ecological disciplines: Macro-invertebrates, fish, birds, dragonflies, mammals, vegetation, amphibians and the water chemistry. These investigations were conducted on several different locations around the year. The monitoring program is to be completed by surveys and analysis in 2005. In Wien River reservoir 6 and 7, the monitoring program is continued in the 2002 to 2004 to document and control the ecological impacts of the railway tunnel construction. The data available at our department are mainly taken from final reports of each discipline, representing processed data and expert analysis partly with regard to the EU-WFD (in German). Some of the ecological data was processed in a GIS environment. It should be generally possible to get the raw data, but it may take a while and some effort to convince the specialists to pass the data to URBEM. Chemical investigations are completed by analysis from the Federal Environmental Agency (UBA). The time series of all investigated parameters are requested for. As these investigations are part of the legal mandate of determining the state of water bodies in Austria, these figures will also be measured in future.

12.1 Chemical data

The sampling sites are exhibited in the PowerPoint-map. The complete list of raw data from the Federal Environmental Agency (UBA) is requested for. Beside the sample site in the map (FW91401817), UBA is also analyzing water chemistry in an upstream section of Mauerbach (FW91400637) and a downstream Wien River site, 1.2 km from the mouth (FW90301867). A complete list of parameters and a parameter code description is provided. More information on the parameters (in German):

http://www.ubavie.gv.at/umweltsituation/wasser/wgev/arbeitsgrundlage.htm

The investigated site location code is:

WGEV-MST-NR:	**Name**	**Location**	**Salmonides (S) – or. Cyprinides (C) river** EU-Fishing waters guideline (78/659/EWG)	Mountainous (B) - Lowland (F) river **(Draft General Immission regulation f. fishing waters, Aug. 95)**
FW91401817	Wienfluss-Ludwigg.	Wien-Penzing, boundary Wien – Lower Austria	S	B
FW90301867	Wienfluss-Stadtpark	Wien-Landstraße, approx. 1.2 km	C	F

		from the mouth		
FW91400637	Mauerbach (starting January 2003)	Wien-Penzing	Not available	Not available

FW91401817 seems most relevant for our site.

According to UBA, the provided data represent (partly) reliable raw data, which are not processed in detail and which may be subjected to some changes. For publishing the data, I have to sign the commitment to deliver the URBEM output, based on this data to UBA and to refer the following data source:

Datenquelle: Erhebung der Wassergüte in Österreich gemäß Hydrographiegesetz,
BGBl. Nr. 252/90, i.d.g.F.; WWK/BMLFUW, Ämter der Landesregierungen.
Datenbereitstellung durch Umweltbundesamt GmbH Wien, auf Ersuchen vom 23.09.03 (UBA-Zl.:134-270/03).

Data source: Enquiry of water quality in Austria according to the Hydrographic Law,
BGBl. Nr. 252/90, i.d.g.F.; WWK/BMLFUW, Departments of the Federal State Governments.
Data provision on request from 23.09.03 (UBA-Zl.:134-270/03).

Within the ecological monitoring program 1999 – 2001, T. Hein was leading the chemical and sediment analysis. 15 sites indicated in the map were analyzed 2 to 7 times a year. The available parameters can be seen in the xls-sheet example wise for one site.

Balance and dynamics of Nitrogen and Phosphor in the longitudinal section during 3 years.

Sediment samples were taken in October 1999 at the Mauerbach reference site and Wien River basin 2, 3 and 5. Available are D50, the fraction <0.2mm, the sorting coefficient, organic fraction and pore ratio of 4 to 6 soil layers to a depth of about one meter. D50 data is listed in the xls-template.

Physical parameters, relevant for fish-ecology were measured by Keckeis et al., see below.

12.2 Macro-invertebrates

The research in the 1999 – 2001 monitoring program lead by M. Katzmann cover 8 main sites in which measurements were made with standard samplers and the hand net. The locations are indicated in the PowerPoint-

map. In each main site, several typical habitats and sub-habitats (choriotopes) were examined. The results comprise species, biomass, abundances, dominance-structure, a similarity analysis of river-reaches for assessing the connectivity, a longitudinal analysis of feeding-types, a sapro-biological state analysis and a drift-colonization study.
Three main sites were investigated in 2002 by B. Raunig & S. Raudaschl. The locations are indicated in the PowerPoint-map. In each site, several sub-habitats (choriotopes) were examined. Results cover density (abundance) and dominance of individuals and biomass, taxa-presence, analysis of sensitive taxa, EPT-taxa, diversity, evenness and feeding-types.

12.3 Vegetation

Within the 1999 – 2001 ecological monitoring program, the vegetation survey was conducted by I. Korner & A. Traxler (Arge. f. Vegetationsökologie) in a hierarchical way: Small 4 m^2 areas, cross sections up to 114 m length and the entire reservoir as the largest unit.
Characteristic Trends in species types and diversity were exhibited for dynamic and higher-lying gravel areas.
Investigations enclose vegetation cover (species number and diversity) on five reference sites at Wien River, three at Mauerbach and sites in reservoir 1 (Mauerbach), 2 to 6 (Wien River), where a vegetation and relief cross-section was recorded in reservoir 3. The vegetation cover tables of all three year's data on Wien River and Mauerbach are attached (DauerflächenWienfluß-AVL.doc). The table headings contain the site code (e.g. **W50299** with W5 for reservoir 5, 02 for site nr. 2 in reservoir 5 and 99 for the 1999 investigation), the date of the first survey and a description of the site. From the site description, the locationof some sites can be gathered:
The 12 m cross section W101 is located on the alluvial deposits and W102 in a submergesd area of Mauerbach reservoir 1. W201 to W204 are on a approx. 17 m long iland in Wien River reservoir 2, somwhere between km 13.906 and 14.300, where W201 is at the gravel waterfront, W202 and W203 in silty areas, and W204 at the highest iland part. Cross section W 301 (114 m) is located presumably between km 13.649 and km 13.726. Site W302 is located at a gravel iland upstream weir 2, W303 is approx. 20 meters

downstream weir 1. W401 represents a 16 m cross-section on a gravel iland, 25 m downstream weir 2, W402 is also situated downstream weir 2 on silty alluvions. W403 is an reed iland in slack waters, W404 is sited on a gravel iland upstream weir 3. W501 and W502 are found downstream wier 3, W501 is a gravel alluvion with sediments from the lateral tributary Rothwassergraben, W502 has gravel and silty underground. W503 is a pioneer vegetation on a sedimentation area, W504 is located 25 m upstream weir 4. W505 is located at the dryest place in the reservoir, at the northern wall. W506 to W508 are located around a ditch, with W506 is the ditch itself and W507 and W508 are the reeds right ad left of the ditch, respectively. W601 and W602 are fallow land sites, the former slightly submerged, the latter elevated a little higher. W603 is sited upstream weir 6, it was found up to 20 cm submerged and dry during the summer.

Dr. Korner requested me to provide him with an example of our publications.

12.4 Phytobenthos

Algae with due respect to diatoms (indicating the trophies) were analyzed for assessing the Nitrogen and Phosphorus balance along the reservoirs. The four investigation sites are indicated in the PowerPoint map. Sampling dates were in 1999: June 8th, July 20th, October 25th; 2000: January 24th, April 11th, September 15th, October 17th; 2001: May 1st, September 28th, October 17th. The data tables for 2001 are requested for, others could be organized.

12.5 Dragonflies

Dragonflies as indicators for habitat quality and diversity were studied by R. Raab within the 1999 – 2001 ecological monitoring program. 10 main sites were surveyed: 3 sites at the Mauerbach, upstream, in and downstream reservoir 1 respectively, 7 sites on Wien River, comprising reservoir 2 to 6, upstream reservoir 2 and the bypass channel. The main sites were further subdivided into 31 observation locations. Observations (species and reproduction) were made from April to September. Results are available for individual species, abundances and a status class informing about specie’s origin (native/guest) and abundance. These data refer to the whole investigated Mauerbach and Wien river area. Further information is available on the status class per year and main site, whole area and typical habitats, respectively.

12.6 Fish-ecology

The study, lead by H. Keckeis focused on the impacts of rehabilitation measures on Wien River and Mauerbach on the fish-species and abundances, population and reproduction. Parallel, physical parameters were measured on 27 locations, indicated in the PowerPoint map: Electric conductivity, pH, temperature, oxygen saturation, depths, flow velocity (available as means and standard deviation), and water levels at gauge Hadersdorf.

Data are available for fish species, number and abundances (ind. per minute; ind. per m^2), guilds (according to the preference of flowing water) for each year and for the entire Mauerbach sites and Wien River sites. Biomass (weight – length relation), length per specie are given for both rivers in 1999, 2000 and 2001. Histograms on fish length are available for all species and years. The surveys were conducted quarter-annual.

For *Salmo trutta f. fario* (Brook trout) and *Leuciscus caphalus* (Chup, largest abundance), refined investigations focus on the age-structure, reproduction behavior, growing, mobility and dependence on environmental factors. This required monthly fishing on selected sites in the March 2001 to February 2002 period, marking of individuals and a survey on abiotic parameters (flow velocity, sediment, river bank, vegetation and shadowing). The sites at Wien River sites are marked in the map. For these sites, dominance, abundances for adult brook trout and chup are available further length distribution and spawn maturity and mobility indices.

Juvenile fish abundances were derived by quarter-annual fishing for 1999, 2000 and 2001. The ratio of juveniles and adult fish is available for each specie or each site, respectively. Tables show the reproducing species and individuals per minute. Mean annual species, and mean and total annual juvenile individual number are given for all three years.

The fish-ecological monitoring sites in 2002 are marked in the map, measurements were taken on 08/09 May, 28/29 June and 23/24 September 2002. The parameters, listed in tables are:

Physical parameters:

Temperature, pH, el. conductivity, oxygen content –and saturation.

Habitat parameters:

Widths and surface area of water body, depths, flow velocity, sediment, river bank type, -vegetation & slope, shadowing.

Adult fish:

Species & individual number, length & weight per individual

Juvenile fish, caught during the September session:

Species & individual number, length & weight per individual

These figures are available for the three measurement dates and in terms of annual means of physical parameters, species number and abundances.

12.7 Amphibians

G. Gollmann was studying amphibians with a focus on frogs within the1999 – 2001 ecological monitoring program. At the Mauerbach reservoir and oat Wien River reservoir 2 to 5, spawn-mapping by daily inspections and surveying of polliwogs and shouts was performed. The spawn map locates the spawn detected 2001, another map documents the reproduction, regular and singular observations of *Rana dalmatina* (Agile frog) and *Rana temporaria* (Grass frog). For the Mauerbach reservoir, the number of clutches of both frog species is available from 1995 to 2001.

12.8 Mammals

Mammals were studied in the 1999 – 2001 monitoring program by J. Sieber and G. Ulbel. For “Larger mammals”, a species list can be given with the location of their detection, i.e. a reservoir number; these species are rather mobile . The colonization of Wien River reservoirs from 1991 to 2000 by *Castor fiber* (beaver) can be documented.

A list of several species of “small mammals”, which were detected in the period between 1997 and 2001 in reservoirs 1 to 5 and along the channel is available. The study also assigns the preferred habitat types to the species.

12.9 Birds

The research on avifauna in the ecological monitoring program 1999 – 2001 was conducted by R. Zink et al. based on territory mapping during the breeding season and weekly inspections. Visually and acoustically detected individuals were mapped in 50*50 meter raster cells covering the rehabilitated area of Mauerbach and Wien River. The following data and results are available: Total number of cells, where each of the 120 detected species were observed in the 1999 – 2001 period. A table of breeding species. Maps of 12 characteristic species: Breeding maps of 9 species and observations of 3 nutrition guest species. An example is indicated in the PowerPoint slides. A corresponding map is also developed for the “red list”-species.

13. Precipitation data

Time series of the largest available length of daily, monthly and annual totals were requested for those precipitation measurement sites indicated with a name in the map. A summary of the available time series length and the precipitation gauge numbers are given in the “stream and rain gauges.xls”. Unfortunately, the data file-names start with another precipitation gauge number and end with .ixx for annual, .im0 for monthly and .it0 for daily totals. The station names (see map) are indicated in each file heading. IN the data summary xls-file, 5 daily station data are marked with ZAMG (Central Institute of Meteorology and Geodynamics) which are not provided cost free. They can be organized on request.

The longest series of electronic data obtained by the Hydrographic Central Office (HZB) cover 1971 to 2001, for some stations, additional monthly totals series from 1961 to 1991 are provided by V. Weilguni, HZB, BMLFUW Wien in the Austrian Digital Hydrologic Atlas, (digHAÖ, 2003).

Further, the regionalized mean annual precipitation is indicated on a map.

14. Discharge data

A time series of mean daily flows at gauge Kennedybrücke is provided by the Vienna Municipal Hydraulic Engineering Department MA45. From this series, the base flow index is determined.

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