POSTERS

Role of the littoral area as a part of an optimal model for environmental monitoring and the involvement of local people - Presentation of the LIFE Vuoksi project

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1 Background

The littoral area is an essential part of the drainage basin. It is an area where many human activities have effects which alter the ecological status of the lake. Many parameters can be used to measure these alterations and to give an indication of the status of the water body. Physical-chemical data on water quality combined with biological data gathered especially from littoral areas would prove most useful for assessing the ecological status. Taking into account these elements is also required when implementing the EU Water Framework Directive (WFD).

The littoral zone is an important area for recreational use and therefore of high interest for the local inhabitants. The local people and stakeholders should be better informed of the status of the lakes and rivers and of the relation between the water quality and the activities on the catchment area. Also the observations of the environment made by local people should be better used as an indicative part of the monitoring system. Activities like this will be needed to involve the local people and stakeholders in the implementation of the WFD.

2 Aim of the project

The overall objective of the project is to plan a cost effective, integrated monitoring system for the Vuoksi River Basin. The Vuoksi River Basin is located in the eastern part of Finland, which is extremely rich in lakes (Fig. 1).

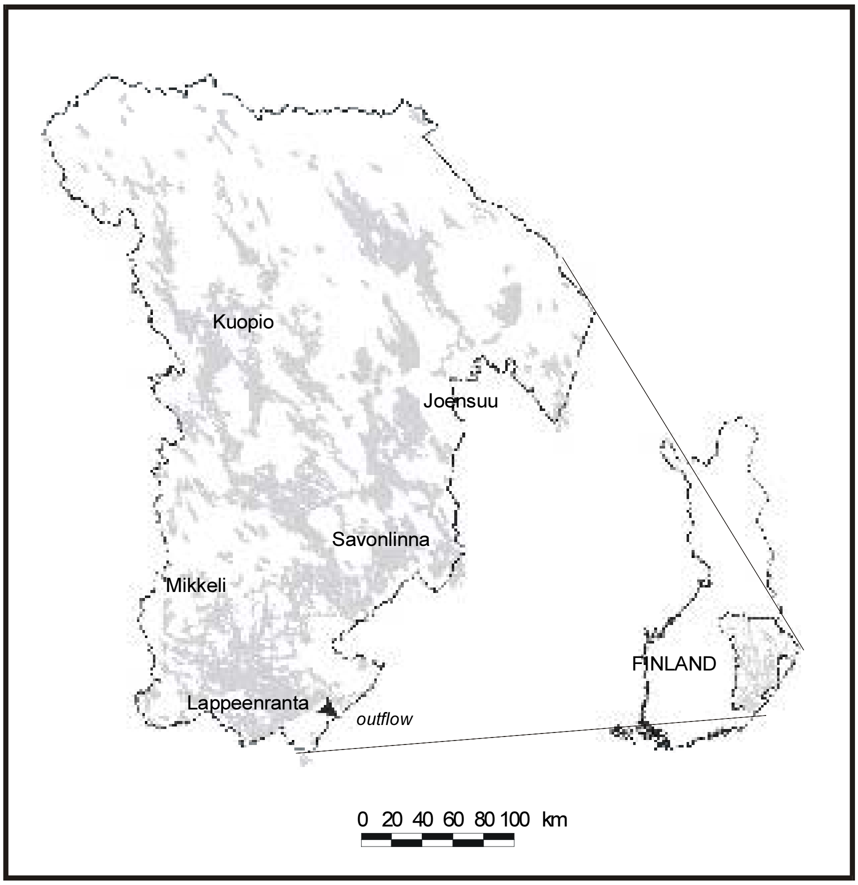

Figure 1. Location and map of the Vuoksi River Basin.

The monitoring system will take into account especially parameters of the littoral areas but combined to the data from open water areas. The aim is to provide a tool for the management of water quality in river basins in general.

The following key objectives can be specified:
- to plan a pilot structure for a cost effective ecological monitoring system concentrating mainly on the littoral zone
- to clarify the pressures to the littoral zones and the connections between them and the land use
- to evaluate the usefulness and cost-effectiveness of monitoring methods for macrophytes, macrozoobenthos, periphyton and phytoplankton
- to improve the involvement and participation of local inhabitants and other stakeholders

3 Project activities and partners

The activities of the Life Vuoksi project are organised to Work Packages, which however are closely linked to each other (Table 1, Fig. 2). One of the starting activities of the project is the evaluation of the existing biological and water quality data (WP 1). For analysing the quality and extent of the existing biological data a metadatabase for materials and references will be gathered. Selecting more precise target areas within the Vuoksi River Basin is also among the first activities (WP 2). It is foreseen that 10-20 lakes with their watershed areas will be selected for more intensive studies. They will represent lake types and loading pressures most typical to the region. In addition to the existing biological and water quality parameters the information of loading and water protection activities is gathered from the target areas (WP 3).

Table 1. Work Packages (WP) of the Life Vuoksi project.

WP	Title	Time schedule
1	Evaluation of existing data	04/2001 – 03/2002
2	Selection of target areas	04/2001 – 09/2001
3	Evaluation of impacts and needs for protection measures	06/2001 – 04/2003
4	Selection of methods	04/2001 – 03/2004
5	Fieldwork and parameter testing	05/2001 – 03/2003
6	Model for an optimal monitoring programme	04/2002 – 03/2004
7	Dissemination of the resulting information	04/2001 – 03/2004
8	The role of the local people and local authorities	04/2001 – 03/2004
9	Management of the project	04/2001 – 03/2004

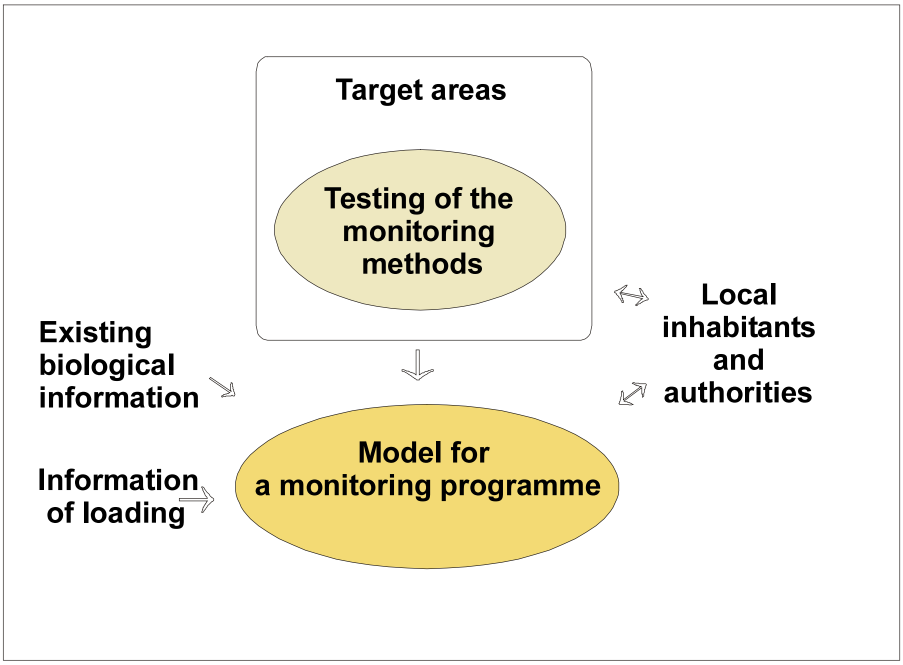

Figure 2. Flowchart of the phases of the Life Vuoksi project.

Review and evaluation of the methods suitable for the measuring of the biological parameters are needed in order to be able to classify lakes in terms of ecological quality (WP 4). Testing the methods in the field will take place mainly 2001 and 2002 (WP 5).

After the fieldwork and parameter testing the creation of a model for a monitoring system will take place during 2002-2004 (WP 6). Combining and improving the existing separate and in themselves insufficient monitoring efforts, especially when littoral areas and biological parameters are concerned, are essential to obtain a optimal system for monitoring the ecological status of the surface waters.

The dissemination of the activities and results will be an important part of the project as well as the involvement of local people (WP 7 and 8). Making an information package for local people will be an important task. The possibilities to better integrate the observations made by local people to the monitoring system will be studied.

There are five partners in the project. The three Regional Environmental Centres: South Savo, North Karelia and North Savo, are each responsible for a special parameter group and in addition to that provide regional knowledge and expertise. Finnish Environment Institute is responsible especially for planning the monitoring system and overall expertise of implementation of the WFD. The University of Oulu provides expertise of using remote sensing methods. The project (1.4.2001 – 31.3.2004) is receiving financial support from the EU Life Environment Fund.

4 Expected results

A pilot, cost effective and integrated system for monitoring the ecological status of Vuoksi River Basin, based especially on the littoral zone, is developed. The most suitable methods for monitoring the biological parameters, macrophytes, macrozoobenthos, periphyton and phytoplankton, will be selected.

The local stakeholder groups and inhabitants will know more about the ecological status of the local lakes and about possibilities to improve the status of their environment as well as about the implementation of the WFD.

Establishing reference conditions in shallow lakes: The potential of palaeoecology

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1. Background

The European landscape abounds with shallow lakes. Small artificial field ponds and large natural waterbodies such as Lake Balaton in Hungary are both examples of shallow lakes where the average water depth is less than 3 m allowing aquatic plants to colonise the majority of the lake basin.

There are, however, very few shallow lakes that have not been affected by the process of eutrophication. This can result in substantial changes in the ecological structure and functioning of shallow lakes. Typical symptoms include 'choking' growth of water plants, reductions in plant diversity and the development of bloom-forming populations of phytoplankton. In extreme cases there is a complete loss of submerged vegetation and a switch to a turbid, phytoplankton dominated state with a dramatic reduction in habitat diversity and hence biodiversity.

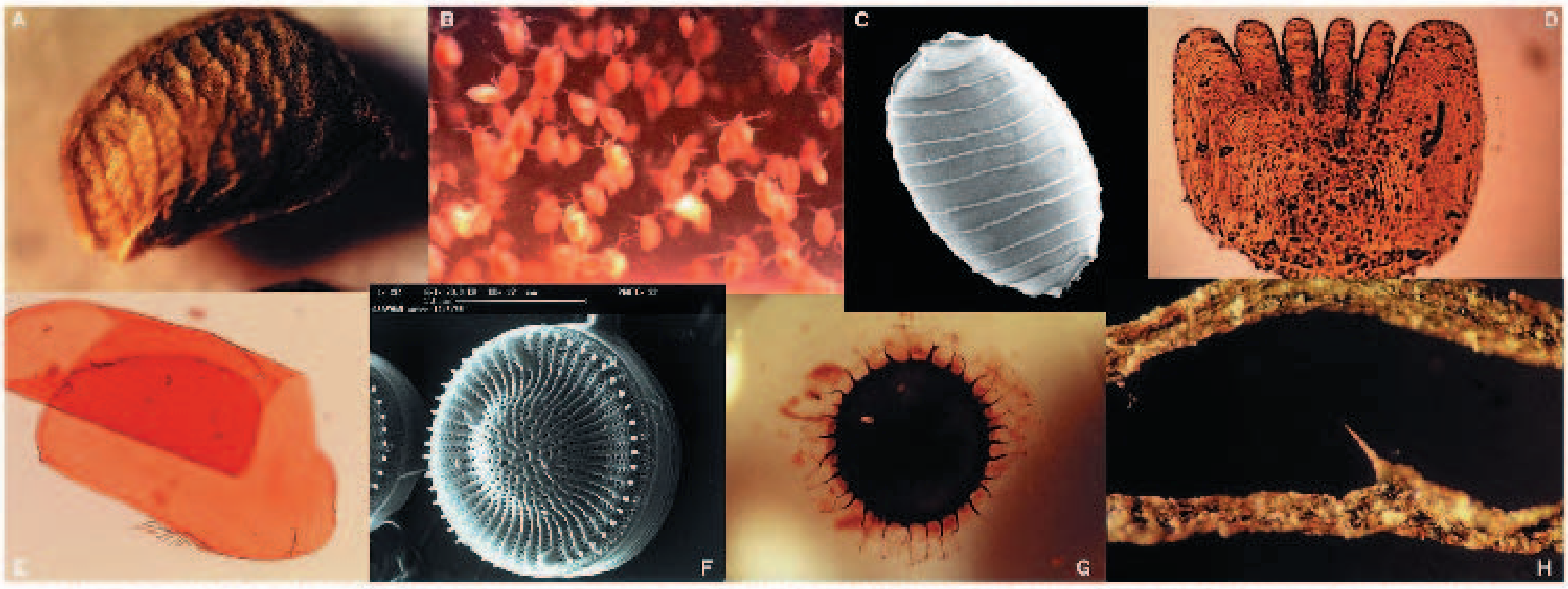
Clear water, plant dominated lake

Blue-green algal bloom

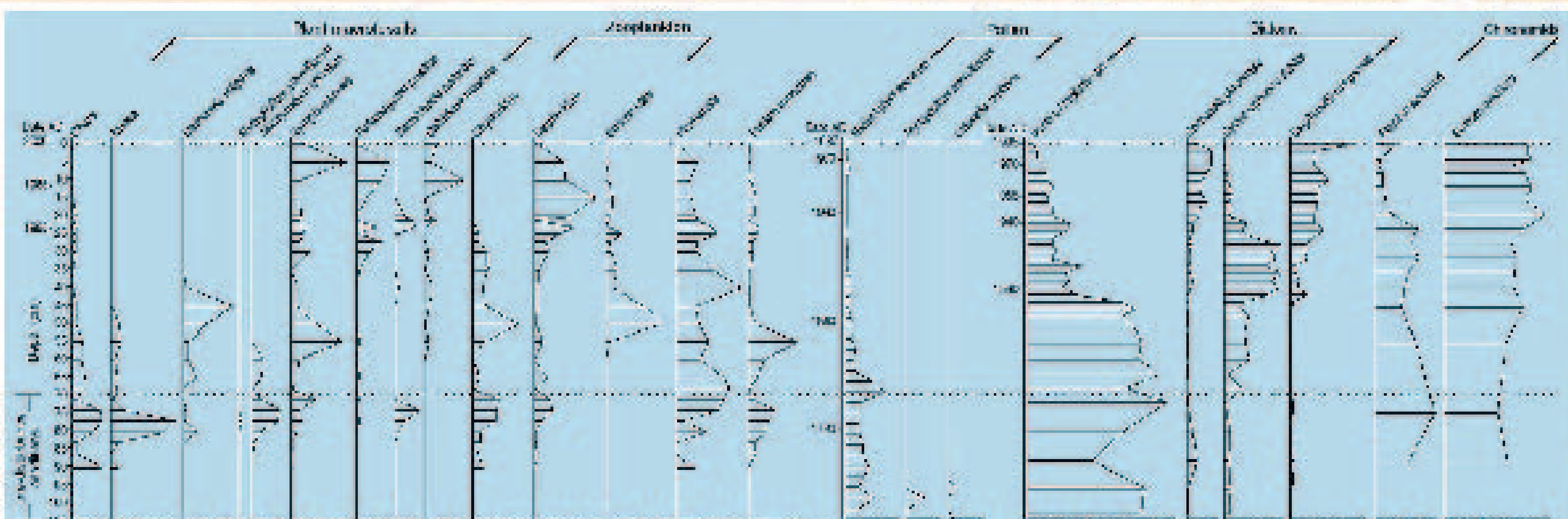
2. Reference conditions and the potential role of palaeolimnology

One of the key aims of the Water Framework Directive is the determination of 'reference conditions' for different lake types which accord to a pristine, or near pristine state.

In the absence of historical data palaeolimnological techniques can play an important role in determing past lake conditions. A variety of biological groups are preserved in lake sediments, representing all parts of the food-web: algae (diatoms), macrophytes (macrofossils, pollen), zooplankton (Cladocera), macroinvertebrates (molluscs and bryozoans) and fish (scales). Analysis of these remains in sediment cores can be used to track changes in ecological structure and determine reference conditions.



A - *Ranunculus* seed, B - *Daphnia*, C - *Chara* oospore (SEM image), D - Fish (Percid) scale, E - *Acroperus harpae* carapace, F - *Cyclostephanous tholiformis*, G - *Cristatella mucedo*, H - *Utricularia vulgaris* spine



Summary stratigraphy of selected palaeoecological groups. Aquatic plant macrofossils, zooplankton ephippia, *Plumatella* statoblasts, testate amoebae (GROB4); aquatic pollen, diatoms and chironomids[3]. (Radiometric dates are shown where available. Numbers for *Littorella uniflora* x 5 exaggeration).

3. A case study: Groby Pool

Groby pool is a shallow lake in the midlands of England. Sediment cores from this site have been subject to multi-indicator palaeolimnological studies. These data indicate that eutrophication has had effects that cascade through all trophic levels with a post 1850 AD shift towards 'eutrophic' macrophyte taxa and dominance by planktonic forms (e.g. Cyclostephanoid algal taxa, *Bosmina*/*Daphnia*). The lower sections of cores from this site can be used to define pre-disturbance biological communities. They indicate a diverse, 'mesotrophic' macrophyte assemblage (e.g. Characeae, *Myriophyllum alterniflorum*, *Myriophyllum spicatum*, *Utricularia vulgaris*, *Littorella uniflora*), dominance by benthic diatoms (*Fragilaria* spp.) and plant-associated Chydoridae and chironomids.

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Eco-hydro-morphological Model Development for a Stream Restoration Scheme

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Introduction

Heavy regulation activities at rivers and streams contributed to an increase of flood events and a decrease in diversity and abundance of ecosystems over the last century. Thus restoration is required in many rivers world-wide. 'Natural' channel and floodplain designs have recently been envisaged, including the integration of meanders, minimum use of bed armouring material and structures, which promote habitat diversity. Trying to meet both hydraulic stability and ecological requirements, the engineer is currently confronted with conflicting design parameters – the need to protect the physical integrity of the stream whilst sustaining biodiversity. Davies (1989) proposed a classification which incorporated the combined effects of velocity, depth and substrate roughness providing a means of quantifying the flow regimes occurring within the microhabitats of stream benthos.

In order to successfully create, manage and enhance various ecological habitats, it is essential to understand flow characteristics and morphology of river channels. Imposing inappropriate hydraulic conditions can lead to instability of the bed and maintenance problems (Hey and Thorne, 1986). Velocity and bed material characteristics are significant determinants of biological production and diversity in streams. Linking the ecology to a hydrodynamic model will improve the understanding of factors enhancing ecological diversity and habitat creation.

Case Study

A 4 km long section of the Afon Morlais, a small stream in West Wales, UK, was monitored over a period of 1.5 years, starting directly after it had been reinstated along its original route over a disused 'open cast' coal mine. The river was acknowledged as of a good quality and significant fisheries resource. Previous reinstated watercourses in the area were designed with armouring sufficient to prevent any erosion, resulting in an 'over engineered' appearance with little opportunity for the development of gravel beds, point bars, pools and riffles. To encourage natural development, an erodible, trapezoidal channel, including an up to 50 m wide floodplain, with no armouring and a series of severe meanders was constructed. The stability of the 'natural' design was compromised by highly varied flow rates (0.075 m3/s baseflow to up to 5.7 m3/s in an annual flood event), changes in bed slope over the full length (from 1 in 11 to 1 in 160), the severity of the meanders and the shallow cover layer (approx. 2 m) with a high proportion of fine material. The monitoring and the numerical predictions were undertaken to show whether these constraints had been successfully incorporated into the design.

Flow and sediment transport modeling

At present, little information is available about the design and maintenance of 'natural' river restoration schemes, combining hydraulics,-morphodynamic and habitat conditions. This combined field and numerical modelling study seeked to redress this situation by first using two computer modelling tools: The 1-D model HECRAS for predicting velocities and water depths longitudinally and the Research Centre's 2-D, finite difference model DIVAST, which was applied for several meanders taking account of the cross-sectional velocity and depth distributions.

The 'natural' design, with the aim to maximise habitat creation, required that bed armouring material of the smallest size possible was used. An additional program was developed to determine the necessary sediment size to prevent the initiation of sediment motion. The program calculated the values for specifying the critical Shields parameter from the results of the two numerical models and, in a next step, the critical sediment sizes. The calculated critical sediment sizes closely identified regions where erosion was occurring. The numerical models correctly predicted water depth and velocity distributions.

Conclusions

An integrated 1-D/2-D hydro-morphological tool has been developed, predicting velocities, water depths and the sediment sizes, which are necessary to prevent initiation of motion. Results have shown that the program is able to predict observations made at site and that it would be a valuable tool for use in similar design works in future. Bed levels surveys as well as model predictions showed that the stream has not yet reached its equilibrium, as there are still changes in the morphology and the flow regime. It was found that for the design of small meandering streams, a 2-D model is required to represent cross-sectional velocity, depth and sediment distributions in the bends, whereas a 1-D model is sufficient for the straight sections.

It was also found that various disciplines have to be brought together to create sustainable watercourses, which meet hydraulic stability and at the same time ecological requirements. 'Specialised' or integrated models need to be developed to address the specific problems occurring in river restoration schemes and can serve as useful decision support systems.

Future work

Future work will involve the development of a linked 1- and 2-D hydro-morphodynamic integrated numerical tool, which takes account of bathymetry changes. This tool will have the potential to be linked to the ecology of the stream through Habitat Suitability Curves in order to study hydro-morphodynamic influences on habitat creation.

References

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Hey, R.D. and Thorne, C.R., 1986, Stable channels with mobile gravel beds, Journal of Hydraulic Engineering, American Society of Civil Engineers, Vol. 8, No. 112, pp.671-689.

Eco-hydraulics Model Development for a Stream Restoration Scheme

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Main questions

- What influences have hydro-morpho-dynamic changes on the rehabilitation process of rivers?
- How can the creation of diverse habitats for flora and fauna be improved?

Aim:
Development of a 2-D eco-hydro-morphodynamic Model

Eco-hydro-morphological modelling tools

1) Development of linked 1-D model to predict required bed armour material sizes

HEC RAS ⇔ Initiation of motion model

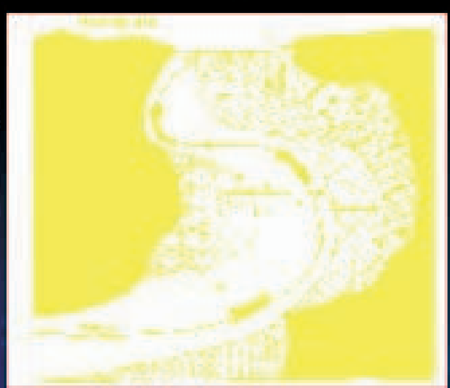
2) Applying 2-D hydrodynamic model to meandering stream and linking dependencies of creation of habitats

DIVAST ⇔ Habitat Suitability Index Curves

⇒ Tools for design of sustainable rivers

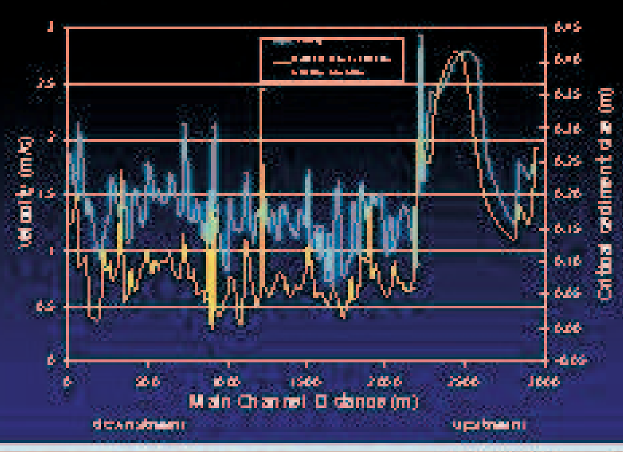
Restoration scheme

- Meanders
- Steep and shallow banks
- Riffles
- Movable Bed



'Natural' Stream Design Approach

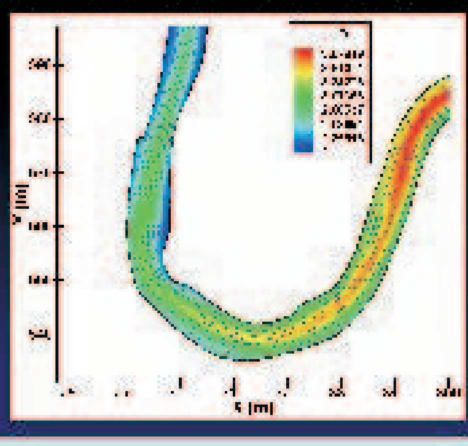
1-D Hydro-morphological Results



Unstable Bed

Additional Armouring

Curvilinear 2-D hydrodynamic Model: Contours and Velocities



Conclusions

- Development of 1-D hydro-morphological model predicting initiation of motion
  - Application and calibration for 3 km stream section
- Application of curvilinear 2-D hydrodynamic model
  - Prediction of cross-sectional velocity distributions for meanders

Future Work

- Development of 2-D hydro-morphological model predicting bathymetry changes
- Definition of Habitat Suitability Indices
- Modelling effects of diffuse source inputs

⇒ Prediction of habitat conditions and the recolonisation processes in rivers

⇒ Improved understanding of factors influencing and enhancing ecological diversity and habitat creation