GEOGRAFICKÝ ČASOPIS

59 2007 2

*Milan Lehotský, Anna Grešková**

FLUVIAL GEOMORPHOLOGICAL APPROACH TO RIVER ASSESSMENT – METHODOLOGY AND PROCEDURE

M. Lehotský, A. Grešková: Fluvial geomorphological approach to river assessment – methodology and procedure. Geografický časopis, 59, 2007, 2, 22 tabs., 44 refs.

In the last two decades, the management of rivers has developed into the form of a multifunctional procedure built upon the holistic base that unites scientific knowledge, engineering interventions, control of pollution, water resource management, fisheries, transports, energy economy and protection of rivers. The paper presents a review of basic groups of publications in the field. The methodology of river morphology assessment based on ideas of the role of thresholds in river morphology sensitivity, and stages of aggradation and degradation of channel and floodplain morphology are regarded as principle tendencies of river morphology change. Secondly, the article shows the basic features of the geomorphic assessment framework of rivers. The main principles of the assessment procedure consisting of comparison between the properties of river reach and reference reach conditions are designed. The proposed framework includes guidance on sample site selection, field procedures and the scoring system for the assessment as well as guidance on training, certification and intercalibration procedures. The assessment is based on the principle that the highest quality is obtained when the hydromorphological conditions are as close to the reference situation as possible and when the spatial variation is as large as possible.

Key words: river morphology, parameters, survey, assessment, hydromorphological quality

* Geografický ústav SAV, Štefánikova 49, 814 73 Bratislava, geogleho@savba.sk, greskova@savba.sk

INTRODUCTION

In the last two decades, the management of rivers has developed into the form of a multifunctional procedure built upon a holistic base that unites the scientific knowledge, engineering interventions, control of pollution, water resource management, fisheries, transport, energy economy and protection of rivers. Adoption of such platform makes it possible to realize *a priori* that any disharmonic or non systemic intervention into the basin or river system is not relevant only at a local level but the response affects the whole basin. The time of the presumed response in integrated multidisciplinary water management schemes is 50 to 100 years. Meanwhile, it is obvious that the multidisciplinarity and prolongation of the vision require adequate environmental legislation. The traditional engineering interventions in the form of implementation of other than natural conditions have destabilized water streams by modification of the channel cross section and runoff-sedimentation regime, while the creation and perhaps even more the maintenance of such conditions require a great volume of capital demanding engineering work. Today, it is necessary to rehabilitate such modified river reaches and return to the sustainable state. Although it is not simple, there are projects in the world that try to maintain a healthy morphological and biotic state, recover the river bed meandering along with creation of structure of morphological units in the form of river reaches of shallow-depression type, changes of counter-flood dikes and weirs or their removal and creation of the river corridor – river landscape with "liberation" of the river bed for migration, projects stabilizing the bank zones, those involved with rehabilitation of the river bed and the like. Environmentally dimensioned engineering interventions oriented to creation of "more natural" river beds and river landscape which ensure ecological diversity and natural stability of the channel-floodplain geosystems should first of all make use of results obtained from research into these natural entities and formulate visions of the future state of basins and streams. After reaching a potentially sustainable state that harmonizes with the natural assets, the engineering measures can concentrate only on protection and enhancing of the environmental and conservationist values of water streams. Though it should be noted that handling of "more natural" forms and processes always requires a minimum investments for their maintenance.

Fluvial geomorphology has been established in the world as a modern dynamically developing discipline that was able to deepen and itemize its theoretical and methodological basis thanks to the most recent knowledge obtained by detailed field research. In connection with the holistic and hierarchized interpretation and "geographization" of the river landscape research, surveying assessment and monitoring of its morphological basis has become an indivisible part of the management and protection of this landscape type. Integrated research into river landscapes also became topical in connection with global climatic change. Cognition of processes taking place during floods and in dry spells and their effect on fluvial geosystems has not only revealed new dimensions for research into fluvial geomorphology but it has also opened space for collaboration with the related sciences and practices. The results so far facilitate closer collaboration between fluvial geomorphologists and other engineering, biological and environmental scientific disciplines. The basic prerequisite for successful development of fluvial geomorphology and its contribution to planning is first of all the cognition of the water stream and basin structures, as well as the processes that take place there in different time horizons. However, assessment of the actual state, i. e. assessment of these structures and processes is equally important. In accordance with Petts (1995), these ideas might be well summarized in the form of a challenge for future fluvial geography. Apart from the development of fluvial geography as a discipline and methodology applicable to river landscape, this field of geography relies in Slovakia as in advanced countries, on three areas: a) assessment of the health condition of rivers in collaboration with ecologists and hydrobiologists; b) research into flood threats and the response to them; and c) in the area of river and basin management. The paper is a logical follow-up to our previous studies (Lehotský 2002, 2004a and 2004b, Grešková and Lehotský 2004a and 2004b, Lehotský and Grešková 2003a, 2004a, 2004b and 2006, Lehotský and Novotný 2004), the ambition of which was to present the basic features of the methodology of research, cognition and classification of river and basin morphology. Its aim is to introduce the methodological platform and procedures of channel-floodplain system assessment.

METHODOLOGY OF RIVER MORPHOLOGY ASSESSMENT

Recent key books dealing with the fluvial-geomorphological (Gurnell and Petts 1995, Thorne et al. 1997, Thorne 1998, Brown and Quine 1999) and ecological (Gordon et al. 2004) issues point to the fact that assessment of morphology is an integral step in research into channel-floodplain geosystems as the basis of the river landscape. Other publications, which are involved with assessment of river morphology, can be classified into two groups:

Firstly, studies published in recognized specialized journals which concentrate on elaboration of approaches or concepts for river morphology assessment presenting them in broader theoretical and methodological context (Simon and Downs 1995, Montgomery and Buffington 1997, Rowntree and Wadeson 2000, Maddock 1999, Heritage et al. 2001, Brierley et al. 2002, Church 2002, Frothingham et al. 2002, Claque and Turner 2003, Fryirs 2003).

Secondly, manuals and studies which present particular assessments or monitoring procedures relying on the morphological classification schemes of rivers by Rosgen (1994 and 1996), Montgomery and Baffington (1997), or their modifications. An example of such work is the assessment of the rivers of Vermont and British Columbia (Channel Assessment Procedure Guidebook 1996, Kline et al. 2003), banks (Cramer and Bates eds. 2003) in the state of Washington, manual for basin and river assessment in the state of Oregon (Salminen et al. 1999), manuals of river rehabilitation and management (Koehn 2001, Bennett et al. 2000) and those of the riparial zone in Australia (Lovett and Prince eds. 1999). Survey of river morphology constitutes a part of the methodology concerning the survey of river habitats (River habitat survey 2003) in Great Britain. The methodology of the eco-morphological survey significantly enriched by its modification for great rivers has been developed in Germany (Fleischhacker and Kern 2002). Methodology for the assessment of what is referred to as the geomorphological index of rivers (Rowntree and Zirvogel 1999) has been elaborated in the Republic South Africa. As far as the EU is concerned, a complex of activities with the aim improving the state of all surface waters concentrates in the Water Framework Directive 2000/60/EÚ (WFD). The aim of the Directive is to reach an acceptable ecological state of waters defined by biological, physico-chemical and hydromorphological elements. The above quoted suggests the necessity to establish indicative parameters for the hydromophological quality of a stream, that is the hydromorphological indicators of river quality. Their selection is targeted – parameters, indicators of the ecological condition must facilitate ordinal assessment with regard to the type of river and the following ecological functions: morphodynamic quality of habitat and dynamics of runoff. Lehotský and Grešková (2003b), Grešková (2004), Pedersen et al. (2004) presents the method of assessment of morphological properties in a modified form of that developed in Germany.

Apart from the above quoted studies, which helped us to orientate ourselves in the methodology concerning the river morphology assessment there are a great number of studies that more or less only apply or modify the basic ideas contained in the quoted studies.

At the moment of selection of particular methods applicable to river morphology assessment though, it is necessary to realize that no assessment can embrace the total complexity and moreover that the relationships, processes or responses must be considered in the context of anthropic effects. In spite of it, many assessing approaches have been developed which try to bridge this gap by searching for simpler causal relationships and an adequate set of indicators, which relatively sufficiently explain the natural range of variability and behavioural mechanisms attributable to streams.

In terms of procedure, assessment of the morphological properties of rivers always relies on comparisons of a delimited (naturally or artificially) river reach with the referential one which is reconstructed or little affected by anthropic activities and which reflects the developmental trajectory of the geosystem. Delimitation of the assessed reach is done:

a) *As purpose-bound* – the river is simply divided into reaches with equal length, which comply with the aim and exhaustiveness of the assessment.

b) *Intentionally* – if it is only a local issue, and

c) *Stipulating a channel-floodplain unit selected on the basis of properties quoted in the river morphology hierarchic classification* (*RMHC*) (Lehotský 2004b) and by knowing its invariant as a referential sample. The invariant is identified from detailed cognition of the functioning of the channel-floodplain units (character of planform, channel setting in the floodplain, possibilities for lateral and vertical erosion and migration, type of the channel as a taxon, character of development of morphological units, and the like), comprehension of its functioning in the river segment determined by longitudinal profile inclination, size of discharge and basic types of valleys, character of the river zone (Lehotský and Novotný 2004) and finally by basin properties. The assessed river reach is in good condition if its morphological conditions are close to the referential.

Apart from the above said, there exist a number of other important assumptions that must be respected in assessment of river morphology:

1. The "good morphological condition" of a river in an artificially or naturally delimited assessed reach is not the reflection of its maximum spatial

diversity as it is, for instance, postulated in landscape ecology. It is because some types of river reaches are more homogeneous by nature and other in turn, vary more in their essence.

2. The model of hierarchic classification shows that as far as morphological properties of rivers are concerned, there is a set of certain similar taxons or types of assessed reaches. They are entities with specific properties and composition of morphological elements, while every type can be characterized by means of a specific set of attributes that do not agree with those in other types of river reaches, thus assessment can only be carried out by comparison of values corresponding to the attributes of a referential reach of a certain type with the values of attributes of other reaches, but only of the same type. If we know them, we can also decide about the relevance of the particular attribute. Otherwise it is not possible to compare, evaluate and monitor the reaches. This means that only the related types of river reaches can be compared and assessed.
3. Assessment must respect the principles of vertical, lateral and longitudinal linkages. In other words, it is not possible to examine and assess the river bed without its flood plain and on the contrary, it is not possible to disrespect the state of morphology in reaches below or beyond the assessed reach or disrespect the position of the reach in the framework of superior taxons, etc.
4. If assumption 2 is accepted along with the fact that the aim of the assessment is to identify changes in the state of those morphological properties of the river that were affected by humans but also those that were caused by other natural phenomena (climate, tectonics) and their effects are identifiable as consequences of the natural development of the stream whether it was under the impact of sudden events or during the average regime in time horizon of 100-200 years, it seems logical that the taxon which complies with the conditions of appropriateness as the subject of assessment is the channel-floodplain units of RMHC (Lehotský 2004b). Subject of assessment defined in a similar way but under a different name (what is referred to as the *River Style*), also interpreted as the taxon of the hierarchic structure of river can be found in Brierley et al. (2002) and Fryirs (2003). Other authors call these river units used as assessment subjects simply river reaches. The inclusion and comprehension of the development of the channel-floodplain unit at the level of superior taxons (segment, zone and basin with river network) already sufficiently traces the evolutionary trajectory. On the other hand, cognition of the lower taxons it is composed of facilitates cognition and assessment of change symptoms and identification of the morphological "health" condition of the river.
5. The present development of a river must always be seen as the continuation of its development in time, while this aspect of evolution provides possibilities to explain mainly the causes of changes in structure and processes and less symptoms of these changes.
6. It is necessary to discern the morphocentric assessment of the morphological properties of rivers. Morphocentric assessment captures the character of changes in terms of aggradation or degradation. Results can be

used in eco-morphocentric assessment. Monitoring is only a survey done at regular intervals in mostly artificially, metrically and non-genetically set river reaches. Morphocentric assessment should be part of monitoring that is in its preparatory phase, it means during selection and definition of referential conditions, identification of the reach to be monitored and interpretation of the obtained results.

7. The key point of assessment is the identification of thresholds and the setting of threshold values of channel-floodplain geosystem properties. If they are exceeded, the character and type of river morphology changes. For instance, the type of river reach changes in 50 - 100 years. They are detectable only in the field. Threshold values are detected by looking for changes in the character and composition of morphological units, symptoms of changes in channel planform, and the like. Engineering interventions such as bridges, weirs or dams often fulfil the role of thresholds.
8. It is necessary to bear in mind that assessment can be accomplished for various purposes. Then the rate of details of river research and scale of the geomorphological map have to correspond. In the case of streams below 30 metres wide, the map should be at scale 1:500. But it requires adequate technical (GPS, distance meter, GIS, compass, inclinometer, wading rod) or material (fishing boots, raincoat) equipment, a very concrete work plan with specified steps. The map legend uses a specific terminology of fluvial geomorphology and apart from its scale it does not differ substantially from other geomorphological maps.

PROCEDURE OF HYDROMORPHIC ASSESSMENT

The second aim of the article is to present the procedure of a hydromorphic assessment framework, which is based on the methodology applied in Germany for large rivers (Fleischhacker and Kern 2002) and modified to suit Slovak conditions (Pedersen et al. 2004). The framework includes guidance on sample site selection, field procedures and the scoring system for the assessment.

The assessment is based on the principle that the highest quality is obtained when the hydromorphological conditions are as close to the reference situation as possible and when the spatial variation is as large as possible. When a comparison with *the reference situation* is possible, this is given priority. For example, with planform, a good score is given to rivers where the planform is the same as in the reference condition and not to a specific planform (e.g. a straight stream is given a good score if it is also straight in the reference condition). The reference condition is the original state of the river reach before it was affected by human influences. Knowledge of the reference condition is also a prerequisite for correct interpretation of the hydromorphological quality within the concept of the Water Framework Directive (WFD). Old maps are a key source of information for setting the reference condition for some hydromorphological parameters. Field surveys on reference sites may be needed to identify the reference conditions for other parameters. Parameter values may differ between streams even though they are in a reference condition. This simply reflects the natural variation in parameters values found in natural systems. Guidance on how to define river types and individual reaches is given in Harrelson (1994) and the CEN standard (CEN, 2003). The basis for the hydromorphological survey is *the survey unit (SU)* as a portion of river reach. The survey unit is subdivided into 5 sub-survey units (SSU) of equal length. The surveys are carried out in the five SSUs, although some parameters, such as the channel planform of the river bed (e.g. degree of sinuosity) are assessed for longer reaches. The survey strategy is thus hierarchical. The size of morphological forms and features changes as river size increases and therefore the length of the SU and SSUs is scaled according to the size of rivers (Church 2002). A *classification of rivers in three size groups* was proposed for the purpose of defining survey lengths (Tab. 1). The boundaries between river size classes were established based on the evaluation of accessible data concerning river channel width (maps at scale 1:25,000) and field observations. *Channel width* is used as the basis for size definitions rather than discharge because it is easily measured in the field or it can be interpreted from a map or aerial photograph. *The length of the reaches* defined will vary from river system to river system and from upland to lowland streams. The exact location of the hydromorphological survey within the reach will depend on the environmental variation along the reaches defined. The selected survey unit should therefore be representative of the river reach in question with respect to channel morphology, land use, geology and geomorphology. The floodplain parameters, that are included in the hydromorphological survey, are based on the whole floodplain. Riparian vegetation is assessed in a 20-metre wide zone along both sides of the river. All other parameters are based on the stream channel. *Surveys should be carried out during low flow periods* when the riverbed structure and substrate is visible. In addition, the field survey should be carried out in the vegetation period from June to September, as several parameters rely on assessing the vegetation structure. The vegetation period may differ throughout Slovakia due to climatic and topographic differences, and the survey period should be adjusted to the climatic conditions.

Tab. 1. Length of survey units (SU) and survey sub-units (SSU)

River type	Channel width	Length of SU	Length of SSU
Small river	< 10 m	200 m	40 m
Medium river	10 - 30 m	500 m	100 m
Large river	> 30 m	1 000 m	200 m

Survey procedure

The survey procedure consists of five different steps:

1. Collection of data
2. Defining survey units within the reaches
3. Assessing map based parameters
4. Field survey
5. Assessment and presentation

Step 1. Collection of data

Data sources are maps, aerial photographs and GIS layers, as well as maps showing the water body delineation within catchments. The following material can be used for the survey:

- Topographic maps 1:10,000 or 1:25,000 for the definition of the current planform,
- Historical maps for comparison of sinuosity,
- GIS database layers or maps for land use analysis on the floodplain and in the catchment,
- Geological maps (1:50,000),
- Aerial photographs and/or vegetation maps for estimation of the land use and the vegetation on the floodplain and riparian areas,
- Other material regarding water abstraction, reservoir management, etc.

Step 2. Defining survey units within the reaches

River reach and representative sites should be selected based on the methodology given above and the exact location of the survey units and subunits should be determined from a map, orthophoto maps and field surveys. The basis for this work is the delineation of the rivers into water bodies (reaches), carried out prior to the assessment described in this protocol. The locations of the units to be surveyed are marked on a topographic map or in the GIS environment and the exact boundaries of the different survey units and sub-units should also be marked.

Step 3. Assessing map based parameters

Map based parameters include catchment parameters and parameters related to channel modifications. Furthermore, parameters related to river valley form and maps and aerial photographs can also assist in the assessment of land use and floodplain structure. The results can then be checked in the field afterwards. The results are entered in the survey forms. Many site protocol parameters can also be obtained from maps. This should also be carried out prior to the field survey. In some cases the assessment of the map-based parameters will be substituted by expert judgements. This will be the case where map data are unavailable. Expert judgements will typically involve transfer of data or knowledge from similar sites in other catchments or nearby sites up- or downstream from the reach under survey (Thorne et al. 1997).

Step 4. Field survey

The field survey should be carried out in the survey units as defined from maps. Any changes to the location of a survey unit decided in the field should be mapped and documented for future use. The exact location of survey units should be altered only where field surveying is impossible due to restrictions on access to the river. Parameter descriptions (and pictures showing the different features) should be taken to the field in order to enhance the quality of the assessment. The field survey forms should be completed in the field and any map

Tab. 2. Overall landscape features at the sites and in the catchment

Parameter	Description/Source of information
1 IDENTIFICATION	
1.1 Stream (river) name	Name
1.2 Site name	Name
1.3 Number of stream/site	Number
1.4 Name of river system	Name
1.5 Map reference	Number
1.6 Stream order	Number
1.7 Latitude	Co-ordinate
1.8 Longitude	Co-ordinate
1.9 Site altitude (m.a.s.l.)	Number
1.10 River width type	Type
1.11 River type (WFD)	Type
1.12 Sketch/Photo	Picture
1.13 Surveyor	Name
1.14 Surveyor certification number	Number
1.15 Date of survey	Date
1.16 River use	Type
2 CHANNEL AND SITE PARAMETERS	
2.1 Catchment area	Map or GIS
2.2 Distance to source	Map or GIS
2.3 Mean slope of the river channel	GIS or map
2.4 Cross-section type of the channel	Type
2.5 Bank stabilization	Field survey/Type
2.6 Cross section dimensions	Field survey
2.7 Channel plan form (present)	Type
2.8 Valley type	Type
2.9 Presence of migration barriers	Field survey / Expert knowledge
3 RIPARIAN ZONE AND FLOODPLAIN	
3.1 Non-natural vegetation in 20 m riparian zone	Field survey/Type
3.2 Predominant land use on floodplain	Field inspection
4 CATCHMENT ATTRIBUTES	
4.1 Predominant geological structure	Map or GIS
4.2 Predominant soil type	Map or GIS
4.3 Predominant land use	Map or GIS
4.4 Catchment topography (min. and max.)	Map analysis
5 HYDROLOGICAL CONDITIONS	
5.1 Mean flow	Time series
5.2 Changes to the hydrological regime	Field survey/Expert knowledge

survey parameters should be checked whenever possible. The field survey should be carried out by walking along the watercourse, and by wading the stream. For large rivers and waterways, that are too deep for wading, inspections are carried out by boat with occasional landings.

Step 5. Assessment

The site protocol parameters are collected to characterize the overall landscape features at the sites and in the catchment (Tab. 2). The assessment parameters are divided into two main groups, the morphology parameters and the hydrology parameters. The morphology parameters can be separated into four categories: channel form, instream features, bank/riparian zone and floodplain parameters (Tab. 3). Each parameter is assigned a score from 1 to 5, with 1 indicating the “best” state and 5 indicating the “worst” state. The score for each parameter is averaged for the SU, (if the assessment is carried out on the SSU level), and the SU parameter values within each of the four categories are averaged to give a SU category score. The final morphology score is the average of the morphology category (1-4) values. The hydrology category includes four parameters. The final hydrology score is the average of the four parameter scores. This score is not combined with the morphology score. The final morphology and hydrology scores are used to determine the morphological and the hydrological quality classes (Tab. 4).

Tab. 3. List of hydromorphological parameters

Category/Parameter	Obtained from	Score for each
1 CHANNEL PLANFORM		
1.1 Sinuosity	Map/Field survey	SU
1.2 Channel type	Map/Field survey	SU
1.3 Channel shortening	Map/Field survey	SU
2 IN-STREAM		
2.1 Bed elements	Field survey	SSU
2.2 River bed substrate	Field survey	SSU
2.3 Spatial variation in width	Map/Field survey	SU
2.4 Flow types	Field survey	SSU
2.5 Large woody debris	Field survey	SU
2.6 Artificial bed features	Field survey	SSU
3 BANK/RIPARIAN ZONE		
3.1 Riparian vegetation	Field survey	SSU L/R
3.2 Bank stabilization	Field survey	SSU L/R
3.3 Bank profile	Field survey	SSU L/R
4 FLOODPLAIN		
4.1 Flooded area	Map/Field survey	SSU L/R
4.2 Floodplain vegetation	Map/Field survey	SSU L/R
5 HYDROLOGY		
5.1 Mean flow	Data/Other information	SU
5.2 Low flow	Data/Other information	SU
5.3 Water level range	Data/Other information	SU
5.4 Frequent flow fluctuations	Data/Other information	SU

Tab. 4. Delineation of the hydromorphological quality classes defined from the final score

Hydromorphological quality class		Final score
1	High	1.0 - 1.7
2	Good	1.8 - 2.5
3	Moderate	2.6 - 3.4
4	Poor	3.5 - 4.2
5	Bad	4.3 - 5.0

Survey forms

Survey forms are to be completed for each survey unit (SU): *the site protocol and assessment form for the structural features. The site protocol* holds the general descriptions of the SU, including identification, site attributes and catchment attributes. *The site protocol* describes the present state of the river, whereas many of the assessment parameters describe the present state compared to the reference situation. The site protocol includes a number of parameters used to characterize the river and its surroundings. It is also used to identify the survey site and includes many relevant parameters that will enable a variety of analyses. Most parameters can be used to group streams with identical features thereby enabling comparison of hydromorphological and biological parameters among identical streams. *The site protocol consists of 5 separate parts: identification, channel parameters, riparian and floodplain features, catchment features and hydrological parameters.* The first parameters are used to identify the site and the exact location within the catchment. Many of the parameters can be assessed from maps; the remaining should be assessed from other relevant sources. Individual map parameters should preferably be derived from maps with identical scales to ensure consistent parameter estimation. The surveyor, date of survey, and a photo or a sketch of the site is also included in the identification part of the protocol. The survey unit should be situated within slope assessment length. If there are any significant tributaries entering the river or other significant changes to the river planform (e.g. dam) within the defined length, the assessment length should be reduced to exclude these changes in planform. Each parameter affecting the natural conditions at the site is marked an “X” in the protocol. *The assessment protocol* is divided into five categories or groups of parameters. Four parameters are each targeting different aspects of the hydromorphological structure of the river/stream and the fifth targets the hydrological aspects of the hydromorphological quality. All parameters are described below and procedure of scoring is described in Pedersen et al. (2004).

1. Channel planform parameters

The parameters are assessed according to their current state relative to the historical and non-degraded state. They are found by comparing present day features from the 1:10 000 maps with features from historical maps. These parameters should be assessed over longer river channel lengths than the length of survey units for the following multiples of SU length: small river – 3× survey unit length (3×200 m), for medium river – 6× survey unit length (6×500 m), for large river – 6× survey unit length (6×1000 m). If there are any significant tributaries entering the river or other significant changes to the river planform (e.g. dam) within the defined length the assessment length should be reduced to exclude these changes in planform. If no old maps exists or the channel on the old maps shows sign of modification, the three channel parameters have to be assessed by expert judgement. This should include an analysis of the land use, river valley slope, geological and geomorphological conditions, from which the natural type can be interpreted with help from the literature (e.g. Rosgen 1994, Thorne et al. 1997, Thorne 1998). Another possibility is that the historic type and channel pattern can be inferred from a similar site with similar characteristics and data available. Alternatively, remnants of the old channels in the flood plain can potentially be identified on aerial photos, from which the historic channel type, length and sinuosity can be estimated. The Channel planform score (CPS) is calculated as the average of the scores given for channel sinuosity, channel type and channel shortening:

CPS = (1.1 + 1.2 + 1.3)/3

Channel sinuosity (1.1). Sinuosity will be obtained by standard procedure measuring the real length of the river channel and dividing it by the length of the valley (Tab. 5).

Tab. 5. Channel sinuosidy

Historic / Present	Straight	Slightly	Mod. sinuous	Meandering
Absolutely straight (1.00)	4	5	5	5
Straight (1.01 - 1.05)	1	3	4	5
Slightly sinuous (1.06 - 1.25)	2	1	2	3
Mod. sinuous (1.26 - 1.50)	2	2	1	2
Meandering (> 1.50)	2	2	2	1

Channel type (1.2). The channel type according to branching at the present time is detectable from the 1:10,000 maps, historical maps provide its past shape (Tab. 6).

Tab. 6. Channel type

Historic / Present	Single channels	Parallel channels	Braided
Single channels	1	3	5
Parallel channels	1	1	3
Braided, anastomosing	1	1	1

Channel shortening (1.3). The channel shortening value will be obtained by comparison of the present state (length of the river channel in survey units from the 1:10,000 maps) and the state in the past, from historical maps (Tab. 7).

Tab. 7. Channel shortening

Shortening	Score
< 10 %	1
10 - 30 %	3
> 30 %	5

2. In-stream features

The in-stream parameters are assessed in the field and comprise several parameters related to the current conditions in the stream and on the streambed. The in-stream parameters should be surveyed from within the stream. The in-stream features are all evaluated at the scale of the SSU. After the in-stream features have been assessed, the scores of all SSUs are first averaged and then the in-stream feature score (IFS) is calculated as the average of the scores given for the SU, i.e.:

IFS = (2.1 + 2.2 + 2.3 + 2.4 + 2.5 + 2.6)/6

Bed elements (2.1). This parameter gives the number of individual bed elements such as islands, various bar forms and rapids (bedrock bars). If the river is too large for bed elements to be identified, this parameter is excluded from the assessment. The minimum size (either width or length) of the individual structure must reach 1/3 of the channel width, which is defined here as the distance between the left bank and the right bank at the time of the survey at the location of the structure (Tab. 8).

Tab. 8. Bed elements

Number of bed forms \ % of size of SSU	< 10 %	10-50 %	> 50 %
> 3	1	1	1
2	3	2	1
1	4	3	1
None	5		

Bed substrates (2.2). The assessment is carried out while standing in the river. The natural bed substrate is assessed by counting the number of different types that cover more than 5 % of the bed in the SSU. The abbreviations for the substrates that cover more than 5 % of the bed are circled in the assessment form as follows:

Bedrock *(BE)* exposed solid rock,

Boulder *(BO)* loose rocks > 256 mm diameter,

Cobble *(CO)* loose material 64-256 mm diameter, Gravel/pebble *(GR)* loose material 2 - 64 mm diameter,

Sand *(SA)* particles 0.06-2 mm diameter,

Coarse debris *(CD)* Organic matter > 1 mm (leaves, twigs, small pieces of wood etc.),

Silt/mud *(MU)* very fine deposits < 1 mm,

Clay *(CL)* solid surface comprising sticky material,

Peat *(PE)* predominantly or totally peat, organic origin.

If all coarse substrate types (boulder, cobble and gravel/pebble) are present, the SSU automatically scores 1. If the inorganic substrates are estimated to be covered by more than 25 % silt/mud or more than 75 % bio-film (e.g. filamentous algae) +1 should be added to scores below 5. If silt/mud cover is estimated to cover more than 50 %, +2 should be added to scores below 4 and +1 should be added to the score equal 4. If the riverbed is completely covered by artificial substrate the score is 5 (Tab. 9).

Tab. 9. Bed substrates

Number of substrate types	Score
1	4
2	3
3	2
4 or more	1
If mud covers > 25 % or biofilm > 75 %	+1
If mud covers > 50 % and score is 1,2,3	+2
If mud covers > 50 % and score is 4	+1
100 % artificial substrate	5
100 % boulders, cobble, gravel	1

Variation in width (2.3). Variation in width is defined as the largest channel water width divided by the smallest channel water width in the SU at the time of the survey. The width is the distance from the right bank to the left bank perpendicular to the current, independent of whether islands occur in the cross-section. For large rivers, the value is found from topographic maps (scale 1:10,000 or 1:25,000) or on aerial photographs. Man-made structures such as port entries, etc., and small-scale protrusions are not taken into account. For smaller rivers the variation of width is measured in the field. The smallest and largest river widths are measured in each SSU and added to the assessment form. The ratio between the largest and the smallest width considering all measurements within all the SSUs is calculated (Tab. 10).

Flow types (2.4). This parameter is the number of different flow types in the SU. The flow types included in the assessment are based on the flow types defined in the River Habitat Survey (2003) as well in Grešková and Lehotský (2005) (Tab. 11).

Tab. 10. Variation in width

Variation in width	Score
None (1.00)	5
Low (1.01 - 1.25)	4
Moderate (1.26 - 1.50)	3
High (1.51 - 2.00)	2
Very high (> 2.00)	1

Tab. 11. Flow types

Number of flow types	Score
1	5
2	4
3	3
4	2
> 4	1

Large woody debris (2.5). The parameter is the density of large woody debris (LWD) per 1 km. LWD is defined here as trees or substantial parts of trees that are either at least 3 metres long or have a diameter of more than 30 cm for medium sized and large rivers, and for small rivers the dimensions are half of these values. LWD is found in the channel and must be partly under water at the time of the survey. Forty pieces of LWD per km are considered to represent the potential natural state. If aggregations of LWD are present, each individual LWD is counted. This value is based on results obtained in navigable rivers in North America and has been verified during the mapping of the lower course of the Mulde in Germany (Fleischhacker and Kern 2002) and proved by field surveys of small Slovak rivers (Tab. 12).

Tab. 12. Large woody debris

Number of LWD	Score
> 20	1
11 - 20	2
6 - 10	3
1 - 5	4
None	5

Artificial bed features (2.6). This covers constructions such as fairway, bed reinforcement, parallel structures, groynes, ground sills, pipeline crossings and colmatage. Artificial bed features are always made of artificial materials that are not endemic to the stream/river (Tab. 13).

Tab. 13. Artificial bed features

% coverage of length	Score
None	1
Low (< 10 %)	2
Some (10 - 50 %)	3
Many (> 50 %)	5

3. Bank / Riparian zone parameters

Bank and riparian parameters are assessed separately for the left and the right side of the stream in each SSU. The scores for each parameter are first averaged for all SSU and then bank and riparian score (BRS) is calculated as the average of the three bank and riparian parameters.

BRS = (3.1 + 3.2 + 3.3)/3

Natural riparian vegetation (3.1). This includes vegetation in the riparian zone along both channel banks. The riparian zone is here defined as a 20-metre strip with the lower boundary at bankfull stage. Islands are not included in the survey. Note that in the case of trees it is the projected area of the canopy that is used for the coverage and not the stem of the tree. Scores are given according to the extent of the different groups (Tab. 14):

Tab. 14. Natural riparian vegetation

Natural riparian vegetation	Score
Natural	1
Near natural	2
Semi natural	3
Modified	4
Heavily modified	5

Natural: > 90 % natural vegetation. Rest: other vegetation types. No artificial structures or managed land.

Near natural: 25 % - 90 % natural vegetation. Rest: other vegetation types. No artificial structures or managed land.

Semi-natural: < 25 % artificial structures or < 50 % managed land.

Modified: 25 - 50 % artificial structures or 50 - 75 % managed land.

Heavily modified: > 50 % artificial structures or > 75 % managed land.

Bank stabilization (3.2). This parameter is used to assess the restriction of natural lateral dynamics due to stabilized banks and a separate assessment for the left and right bank is carried out. The survey is field based and is carried out in each of the 5 sub-units. The percentage length of the river bank affected by stabilization structures is assessed in the field (Tab. 15).

Tab. 15. Bank stabilization

Extent of bank stabilization in % of length	Score
None	1
< 10 %	2
10 - 50 %	3
> 50 % part of the bank surface affected	4
> 50 % entire bank surface affected	5

Bank profile (3.3). The assessment focuses on the length of natural river-banks in the SSU. The habitat quality of profiled and stabilized banks is considered additionally. The survey is carried out for both left and right bank. The determination of the share of natural banks in a unit requires a field survey for all river sizes. In order to distinguish between natural and artificial banks short descriptions of the characteristic features for each type are given (Tab. 16).

Tab. 16. Bank profile

Length of natural bank	Score
> 90 % natural	1
90 - 60 % near natural	2
60 - 30 % semi natural	3
< 30 % modified	4
0 % heavily modified	5

4. Floodplain parameters

The subject of the assessment is the extent of the current floodplain exposed to frequent flooding compared with the extent of the natural (historic) floodplain and the natural vegetation/land use in the current floodplain. The assessment considers the extent of natural alluvial habitats (i.e. alluvial forest including abandoned channels such as oxbows, side-arm systems and cut-off meanders) and the type of land use in cultivated areas. Undisturbed floodplains are characterized by wetland vegetation, natural forests and/or natural water bodies. These water bodies must be in contact with surface water channel. The floodplain is identified based on geological/soil/morphological criteria (map and field). The assessment is carried out in each of the survey sub-units and on both sides of the river. The results are averaged for all SSUs and sides and then the floodplain score (FPS) is calculated as:

$$FPS = (4.1 + 4.2)/2$$

Flooded area (4.1). The flooded area is here defined as that part of the floodplain that has the potential to be flooded. The subject of the assessment is the retention function of the floodplain and its function as a meander corridor (morphodynamic channel migration). Therefore the actually flooded area must be estimated in relation to the old alluvial floodplain. Flood controlling structures such as guide dykes must be taken into account. The survey and assessment are carried out separately for each section of the floodplain and the L and

R bank. This parameter is only relevant in alluvial valleys. The survey is fully based on maps and existing information (no field survey) and is concentrated in the survey unit. In case of multiple discrete sub-units the entire length from the upstream to the downstream sub survey unit is considered (Tab. 17).

Tab. 17. Flooded area

% of potentially inundated floodplain area	Score
0 %	5
< 10 %	4
10-50 %	3
> 50 %	2
Entire floodplain	1

Natural vegetation/land use on floodplain (4.2). Natural floodplain (floodplain forest, wetland and abandoned channels). The area covered by natural or secondary forest, wetlands and abandoned channels in relation to the total survey section area must be estimated for each side of the river. The share of non-indigenous species may not exceed 10 %. Abandoned channels must be connected to the flow regime of the river (surface connection to the river or connection by groundwater), in order to be part of the natural floodplain area. Land use in remaining area: Only the relation between natural/not natural land use is subject to the assessment score. Registration of the types of non natural land use on each side of the river is to be registered in the site protocol (Tab. 18).

Tab. 18. Natural vegetation/land use on floodplain area

% of the floodplain covered by natural vegetation	Score
> 90 %	1
90 - 60 %	2
60 - 30 %	3
10 - 30 %	4
< 10 %	5
No floodplain	1

5. Hydrological regime assessment

This group of parameters is used to evaluate the effect of artificial impacts on the hydrological regime in the SU. Artificial impacts include changes caused by hydropower dams and operations, abstractions (for irrigation, water supply, etc.) and industrial outlets to the stream. The hydrological quality is assessed by 4 parameters, one describing the change in mean flow, one describing the change in low flow, one describing the change in water level range and one describing the impact of frequent artificial flow fluctuations, all compared to the reference state. Preferably the estimates are based on hydrological records. If records are not available, the parameters are estimated from available data for abstraction rates, outlet rates from power stations, industrial discharges, and so on. Another option is to obtain estimates of mean flow, low flow and high flow from before and after the artificial impact from other sources (recorded observations, general knowledge). The hydrological regime score (HRS) is calculated as the average of the scores given for mean flow, low flow, water level range and frequent flow fluctuations:

HRS = (5.1 + 5.2 + 5.3 + 5.4)/4

Mean flow (5.1). The score is based on the reduction in mean flow from the mean flow in the reference state (Tab. 19).

Tab. 19. Mean flow

Reduction in mean flow	Score
None or minor (app. 0 - 10 %)	1
Moderate (app. 10 - 50 %)	3
Major (> 50 %)	5

Low flow (5.2). The score is evaluated based on the reduction in low flow from the low flow in the reference state. If hydrological records are available, Q_{355} can be used. Otherwise the low flow is the typical flow during low flow periods (Tab. 20).

Tab. 20. Low flow

Reduction in low flow	Score
None or minor (0 - 10 %)	1
Moderate (10 - 50 %)	3
Major (> 50 %)	5

Water level range (5.3). The range in water level is defined as (Hc/Hr)×100, where Hc is the current difference between the mean annual maximum water level and the mean annual minimum water level, and Hr is the difference between the mean annual maximum water level and the mean annual minimum water level in the reference condition (Tab. 21).

Tab. 21. Water level range

Change in water level range	Score
None or minor (0 - 10 %)	1
Moderate (10 - 50 %)	3
Major (> 50 %)	5

Frequent flow fluctuations (5.4). Frequent flow fluctuations occur typically below hydropower plants where the operation of the turbines changes on a short-term (often daily) basis. The score is based on the magnitude of the frequent flow fluctuations, which is assessed as minor, moderate or major (Tab. 22).

Tab. 22. Frequent flow fluctuations

Impact on water level/flow dynamics	Score
None or minor	1
Moderate	3
Major	5

The results of assessment will be presented in five quality classes of hydromorphological state of river channels. The final score of classes of hydromorphological state quality of river channels is identical with the final score of classes of ecological state defined in WFD. The resulting quality of the hydromorphological state represents the degree of deviation of the observed value from the reference state: high state (no or very minor deviation from undisturbed conditions), good state (slight deviation from reference conditions), moderate state (moderate deviation from reference conditions), poor state (high deviation from reference conditions) and bad state (full deviation from reference conditions).

CONCLUSION

River can be viewed as barometers of landscape conditions, or catchments health. Assessments and improvements to river conditions are contingent on researchers, managers, and the community working together to establish sustainable, long-term management strategies that "work with nature". The participation of geomorphologists in the planning phase of engineering will hopefully become established with hazard identification and interpretation. An understanding of the control function that morphological diversity and fluvial dynamics have in supporting biotic populations and ecosystem resilience will also be of increasing importance. The presented geomorphological approach should promote proactive planning and management of rivers, their morphological variability in maintaining channel stability and resilience, channel dynamics, and the sensitivity of systems to change.

This paper was supported by Science Grant Agency (VEGA) of the Ministry of Education of the Slovak Republic and the Slovak Academy of Sciences (grant No 2/6040).

REFERENCES

BENNETT, J., SANDERS, N., MOULTON, D., PHILIPS, N., LUKACS, G., WALKER, K., REDFERN, F. (2002). *Guedelines for protecting Australian waterways*. Camberra (Land and Water Australia).

BRIERLEY, G., FRYIRS, K., OUTHET, D., MASSEY, C. (2002). Application of the river styles framework as a basis for river management in New South Wales, Australia. *Applied Geography*, 22, 91-122.

BROWN, A. G., QUINE, T. A., eds. (1999). *Fluvial processes and environmental change*. Chichester (Willey).

CHANNEL ASSESSMENT PROCEDURE GUIDEBOOK. (1996). *Forest Practices Code of British Columbia Act, Operational Planning Regulation*. Victoria (Ministry of Forestry).

CHURCH, M. (2002). Geomorphic thresholds in riverine landscape. *Freshwater Biology*, 47, 541-557.
CLAQUE, J. J., TURNER, R. J. W. (2003). Record of recent river channel instability, Cheakmus Valley, British Columbia. *Geomorphology*, 53, 317-332.
CRAMER, M., BATES, K., eds. (2003). *Integrated streambank protection guidelines*. Washington (Department of Fish and Wildlife).
CEN14614 (2004). *Water Quality: guidance standard for assessing the hydromorphological features of rivers*. CEN TC 230/WG 2/TG 5:N47
FLEISCHHACKER, T., KERN, K. (2002). *Ecomorphological survey of large rivers*. Manual. Karlsruhe (German Institute of Hydrology).
FROTHINGHAM, K. M., BRUCET, R., HORRICKS, E. E. (2002). A multiple conceptual framework for integrated ecogeomorphological research to support stream naturalization in the agricultural Midwest. *Environmental Management*, 29, 16-33.
FRYIRS, K. (2003). Guiding principles for assessing geomorphic river condition: application of a framework in the Bega catchment, South Coast, New South Wales, Australia. *Catena*, 30, 1-36.
GORDON, N. D., McMAHON, T. A., FINLAYSON, B. L., GIPPEL, CH. J., NATHAN, R. J. (2004). *Stream hydrology: an introduction for ecologists*. Chichester (Wiley).
GREŠKOVÁ, A. (2004). Hydromorfologický prieskum a hodnotenie vodných tokov. In Herber V., ed. *Fyzickogeografický zborník 2, Kultúrní krajina, 16.-17.2.2004, Brno*, Brno (Masarykova univerzita v Brně), pp. 191-195.
GREŠKOVÁ, A., LEHOTSKÝ, M. (2004a). Hydrogeomorphic response assessment of the Danube river channel and floodplain to the 2002 flood events. *Proceedings of The XXII^nd Conference of the Danubian countries on hydrological forecasting and hydrological bases of water mamagement*. Brno (ČHMÚ), CD-ROM.
GREŠKOVÁ, A., LEHOTSKÝ, M. (2004b). Priestorové štruktúry riečnej krajiny In Měkotová J., Štěrba O., eds. *Říční krajina 2*. Olomouc (Palackého univerzita), pp. 44-51.
GREŠKOVÁ, A., LEHOTSKÝ, M. (2005). Morfohydraulická (habitatova) štruktúra dna koryta (príkladová štúdia z Drietomice). In Měkotová J., Štěrba O., eds. *Říční krajina 3*. Olomouc (Palackého univerzita), pp. 81-90.
GURNELL, A., PETTS, G. eds. (1995). *Changing river channels*. Chichester (Wiley).
HARRELSON, CH. C., RAWLINS, C. L., POTYONDY, J. P. (1994). *Stream channel reference sites: an illustrated guide to field technique.* Gen. Tech. Rep. RM-245. Fort Collins (Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station).
HERITAGE, G. L., BROUDHURST, L. J., BIRKHEAD, A. L. (2001). The influence of contemporary flow regime on geomorphology of the Sabie river, South Africa. *Geomorphology*, 38, 197-211.
KLINE, M. , JAQUITH, S., SPRINGSTON, G., CAHOON, B., BECKER, L. (2003). *Vermont stream geomorphic assessment*. Vermont Agency of Natural Resources, Phase 1, 2, 3.
KOEHN, J. D., BRIERLEY, G. J., CANT, B. L., LUCAS, A. M. (2001). *River restoration framework*. Canberra (Land and Water Australia).
LEHOTSKÝ, M. (2002). Korytovo-nivný geosystém – terra incognita v slovenskej geomorfológii. *Geomorphologia Slovaca*, 2(2), 23-30.
LEHOTSKÝ, M. (2004a). Riečna krajina – staro-nový objekt fyzickogeografického výskumu. In Herber, V., ed. *Fyzickogeografický zbornik 2, Kulturní krajina*. Brno (Přirodovědecká fakulta, Masarykova Univerzita), pp. 185-190.
LEHOTSKÝ, M. (2004b). River morphology hierarchical classification (RMHC). *Acta Univeristatis Carolinae, Geographica*, 39, 33-45.

LEHOTSKÝ, M., GREŠKOVÁ, A. (2003a). Geomorphology, fluvial geosystems and riverine landscape (methodological aspects). *Geomorphologia Slovaca*, 3(2), 46-59.
LEHOTSKÝ M., GREŠKOVÁ, A. (2003b). *Hydromorfologický prieskum a hodnotenie vodných tokov Slovenska v súlade s požiadavkami Smernice 2000/60/EÚ.* Návrh manuálu. Bratislava (SHMÚ).
LEHOTSKÝ, M., GREŠKOVÁ, A. (2004a). Riverine landscape and geomorphology: ecological implication and river management strategy. *Ekológia (Bratislava)*, 23, 179-190.
LEHOTSKÝ, M., GREŠKOVÁ, A. (2004b). Hydromorphology, riverine landscape an river management strategy. *Proceedings of The XXII[nd] Conference of the Danubian countries on hydrological forecasting and hydrological bases of water mamagement*, CD ROM. Brno (ČHMÚ).
LEHOTSKÝ M., GREŠKOVÁ A. (2006). Riečna krajina – integrovaný výskum a environmentálne plánovanie. *Acta Facultatis Rerum Naturalium Universitatis Comenianae, Geographica*, 47, 187-195.
LEHOTSKÝ, M., NOVOTNÝ, J. (2004). Morfologické zóny vodných tokov Slovenska. *Geomorphologia Slovaca*, 4(2), 48-53.
LOVETT, S., PRINCE, P. (1999). *Riparian land management technical guidelines.* Canberra (Land and Water Resource Research and Development Corporation).
MADDOCK, I. (1999). The importance of physical habitat assessment for evaluating river health. *Freshwater Biology*, 41, 373-391.
MONTGOMERY, D., BUFFINGTON, J. (1997). Channel-reach morphology in mountain drainage basins. *Geological Society of America Bulletin*, 109, 596-611.
PEDERSEN, M. L., OVESEN, N. B., FRIBERG, N., CLAUSEN, B., LEHOTSKÝ, M., GREŠKOVÁ, A. (2004). Hydromorphological assessment protocol for the Slovak Republic. Annex 2. In *Establishment of the protocol on monitoring and assessment of the hydromorphological elements.* Twinning light Project No. TLP 01 – 29, Final report. Dostupné na: http://www.shmu/File/Implementacia_rsv{twinning/a1_Protocol_Final.pdf (cit: 2004-04-03).
PETTS, G. E. (1995). Changing river channels: the geographical tradition. In Gurnell, A., Petts, G., eds. *Changing river channels*. Chichester (Wiley).
RIVER HABITAT SURVEY IN BRITAIN AND IRELAND (RHS). (2003). *Field survey guidance manual.* Warrington (Environmental Agency of Great Britan, Environmental Agency of England and Wales, Scottish Environment Protection Agency, Environment and Heritage Service of Northern Ireland).
ROSGEN, D. L. (1994). A classification of natural rivers. *Catena*, 22, 169-199.
ROSGEN, D. L. (1996). *Applied river morphology*. Pagosa Springs (Wildland Hydrology Books).
ROWNTREE, K., WADEWSON, R. (2000). *Field manual for channel classification and condition assessment.* River Health Programme Report, Number 13. Pretoria (Institute for Water Quality Studies, Department of Water Affairs and Forestry).
ROWNTREE, K., ZIERVOGEL, G. (1999). *Development of an index of stream geomorphology for the assessment of river health*. NAEBP Report Series No 7., Pretoria (Institute for Water Quality Studies, Department of Water Affairs and Forestry).
SALMINEN, E., KUZIS, K., BAUER, S., RUNYON, J., DENMAN, B., GREENBERG, J., WHINNEY, M. B., ANDRUS, CH., CALDWELL, J. (1999). *Oregon watershed assessment manual*. Oregon (Watershed Professional Network).
SIMON, A., DOWNS, P. W. (1995). An interdisciplinary approach to evaluation of potential instability in alluvial channels. *Geomorphology*, 12, 215-232.
THORNE, C. R., HEY, R. D., NEWSON, M. D., eds. (1997). *Applied fluvial geomorphology for river engineering and management.* Chichester (Wiley).
THORNE, C. R. (1998). *Stream reconnaissance handbook*. Chichester (Wiley).

Milan L e h o t s k ý, Anna G r e š k o v á

FLUVIÁLNOGEOMORFOLOGICKÝ PRÍSTUP K HODNOTENIU RIEK – METODOLÓGIA A POSTUP HODNOTENIA

V celosvetovom meradle sú riečne systémy vo viacerých smeroch pozmenené, destabilizované a narušené, čo sa prejavuje zmenou parametrov ich pozdĺžnych a priečnych profilov, odtokovo-sedimentačných režimov a modifikáciou pririečnych koridorov. Vo viacerých krajinách si nové právne normy, ale aj prax vynútila pre potreby manažmentu, renaturácie a ochrany riečnej krajiny vývoj nových metodík, ktorých súčasťou je aj prieskum a hodnotenie ich ekologického stavu. Vo svete sa realizujú projekty riešiace zachovanie zdravého morfologického a biotického stavu, obnovenie pôvodných pôdorysov riečnych korýt (meandrovanie), spolu s vytvorením štruktúry morfologických jednotiek do podoby riečnych úsekov typu plytčina-priehlbina, zmeny zaplavovaných území, vytvorenie širších riečnych koridorov s následným „uvoľnením" koryta rieky na laterálnu migráciu, projekty zamerané na stabilizáciu brehovej zóny a pod.

Environmentálne dimenzované inžinierske zásahy, nasmerované na tvorbu „prírodnejších" korýt vodných tokov a riečnej krajiny s adekvátnou štruktúrou vnútrokorytových, brehových a príbrežných habitatov, zabezpečujúce ekologickú diverzitu a prírodnú stabilitu korytovo-nivného geosystému, by mali v prvom rade siahať po výsledkoch získaných výskumom týchto prírodných entít a spolu s nimi vytvárať akési vízie budúceho stavu riečnych systémov a ich povodí. V súvislosti s holistickým, integrovaným chápaním riečnej krajiny sa výskum, hodnotenie a monitorovanie jej morfologickej bázy stáva nerozlučnou súčasťou manažmentu a ochrany tohoto krajinného typu. Základom pre úspešné rozvíjanie fluviálnej geomorfológie a jej prínos do plánovacej praxe je v prvom rade poznanie štruktúry vodného toku a povodia, ako aj v nich prebiehajúcich procesov v rôznych časových horizontoch. Nemenej je však dôležité aj posúdenie stavu, t. j. hodnotenie týchto štruktúr a procesov.

V ostatných dvoch desaťročiach vzniklo viacero významných publikácií, pojednávajúcich a približujúcich poznávanie a hodnotenie morfológie vodných tokov. Pri koncipovaní konkrétnych metód hodnotenia morfológie vodných tokov je v prvom rade potrebné uvedomiť si, že žiadne hodnotenie nemôže postihnúť ich komplexnosť v celej šírke. Pritom treba mať na zreteli, že vzťahy, procesy a odozvy musia byť navyše hodnotené v kontexte s antropogénnymi vplyvmi. Aj napriek tomu vznikli viaceré postupy hodnotenia, ktoré sa túto nedokonalosť snažia preklenúť hľadaním jednoduchších príčinných vzťahov a adekvátneho súboru indikátorov, relatívne dostatočne objasňujúcich prirodzený rozsah variability a mechanizmy komplexného správania sa riek. Procedurálne je hodnotenie morfologických vlastností vodných tokov vždy postavené na porovnávaní stavu hodnoteného úseku vodného toku voči tzv. referenčnému, človekom málo ovplyvnenému.

V príspevku sme sa snažili prezentovať základné metodologické východiská hodnotenia hydromorfologického stavu riek, ktoré pozostáva z piatich krokov: 1. zber údajov, 2. definovanie prieskumných jednotiek v riečnom úseku, 3. vyhodnotenie parametrov z mapových a digitálnych podkladov, 4. terénny prieskum, 5. vyhodnotenie a prezentácia výsledkov. Hodnotenie sa uskutočňuje formou terénneho protokolu, ktorý sa skladá zo skupín parametrov vzťahujúcich sa k pôdorysnej vzorke koryta, k charakteru dna koryta, brehov a ripariálnej zóny, nivy a hydrologického režimu. Každému parametru sa priradí odpovedajúca hodnota v rozpätí 1-5. Výsledná hodnota kvality hydromorfologického stavu danej prieskumnej riečnej jednotky sa počíta ako priemer zo skóre parciálnych parametrov. Výsledná hodnota kvality hydromorfologického stavu vodného toku sa prezentuje v piatich triedach a predstavuje stupeň odchýlky od referenčného stavu. Veľmi dobrý stav vykazuje hodnotený úsek vtedy, keď jeho hydromorfologické podmienky sú blízke referenčným podmienkam.