Setting the stage for hydromorphological assessment: delineating spatial units

One of the aims of the REFORM project is to develop a spatial hierarchical framework to assess hydromorphology in rivers. The reason why it is important to adopt a spatially hierarchical method is that the shape and behaviour of a river, as well as the landforms it creates and the habitats that it supports, are controlled by processes at a wide range of spatial scales. In other words, what we see at a river reach is the result of a cascade of influences from further upstream in the catchment. By characterising those controlling influences at their relevant spatial scales, we set the correct context in which to assess the hydromorphological condition of a reach and to develop effective restoration and management options.

The hydromorphological assessment framework consists of three main phases: delineation, characterisation, and the assessment of indicators of hydromorphological condition. All of these three phases are applied to a hierarchy of spatial units within the drainage basin that is being assessed.

Here, we focus on the first step in the framework; the delineation of spatial units. We use information on climate, topography, valley characteristics and channel and floodplain morphology to divide the river system into internally consistent spatial units. We start from the coarsest scale, the region, and work our way through the catchment, landscape unit, river segment and finally river reach levels. Delineation can continue within the reach, where geomorphic units, hydraulic units and river elements can be identified. However, we stop at the reach scale at this desk-based stage of the hydromorphological assessment.

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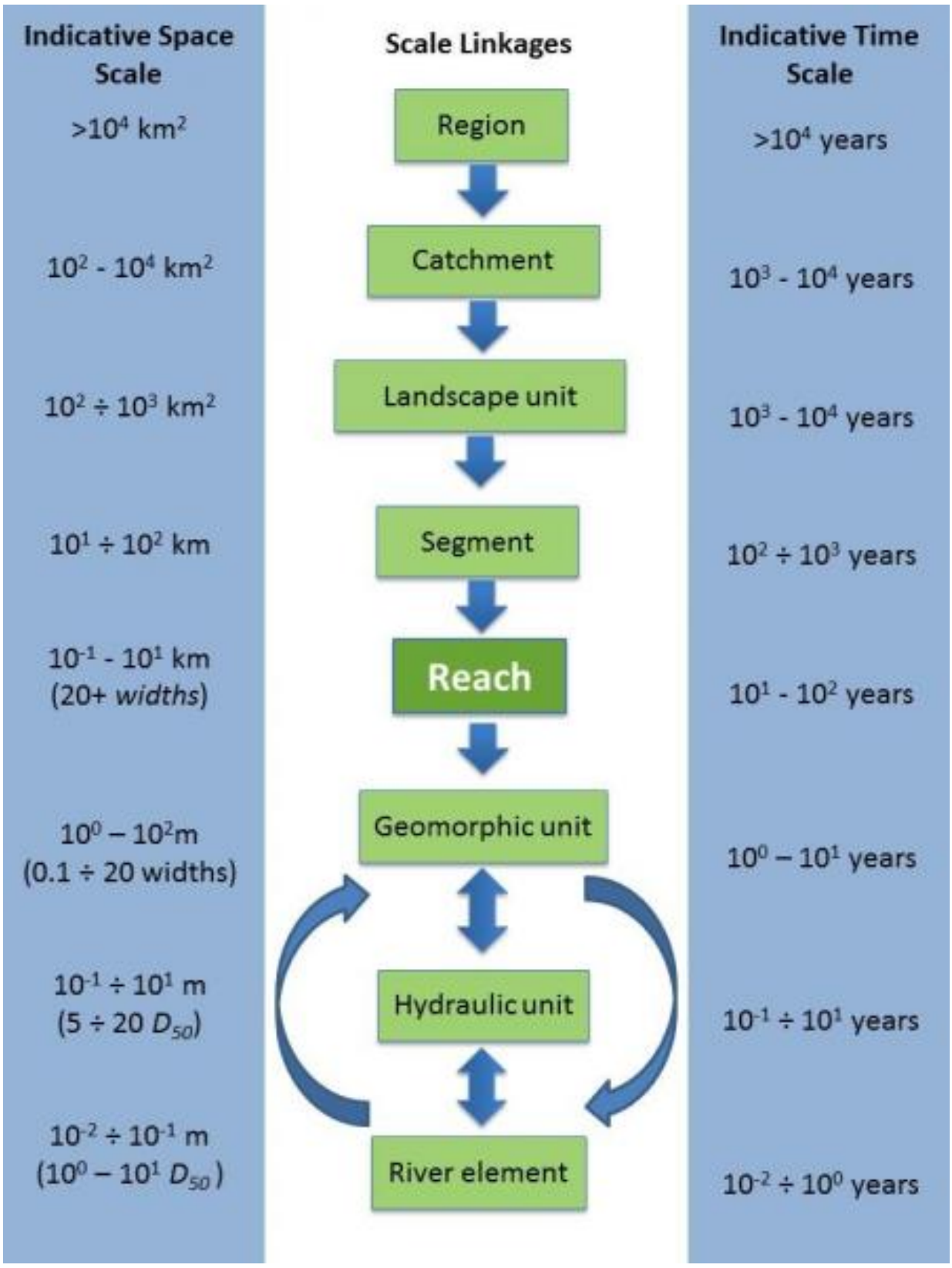

The spatial hierarchical framework for hydromorphological assessment. Image: Angela Gurnell, QMUL

The delineation process is most easily explained by applying it to an example river system, so here we use the River Frome, a lowland groundwater-dominated river in the UK, to illustrate how delineation is accomplished.

Region

The region is a large geographic area that contains characteristic assemblages of natural ecological communities which are the product of broad influences of climate patterns. This scale is important

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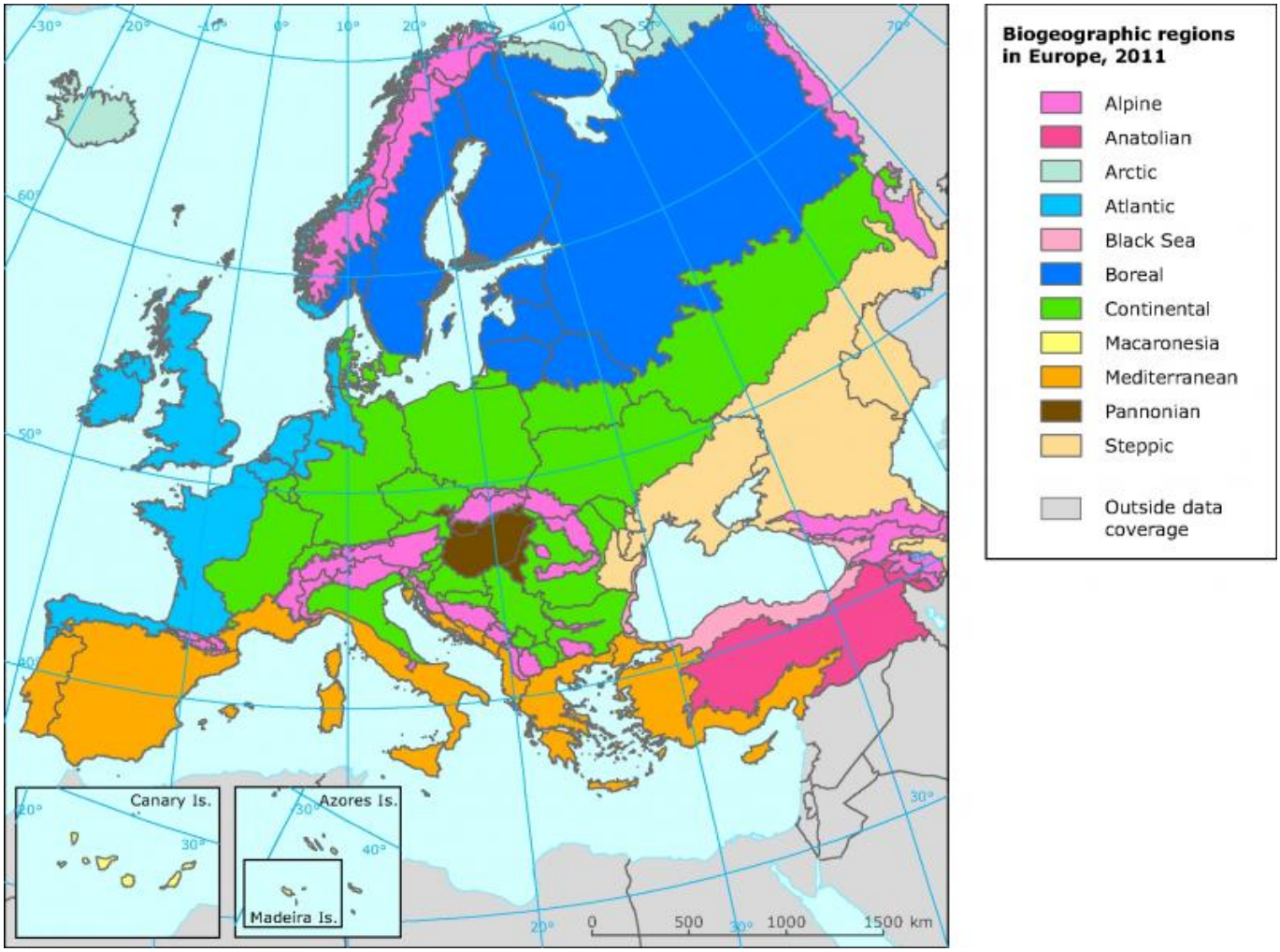
because it is these climate patterns and natural land covers that are the primary controls on all spatial scales of hydromorphological processes. The region can be identified from online maps and publications (www.globalbioclimatics.org; EEA 2002).



The River Frome is located in southern England, which lies within the Atlantic European biogeographic region. The climate is characteristically mild and humid and strongly influenced by the Atlantic Ocean.Image: European Environment Agency 2012, http://www.eea.europa.eu/data-and-maps, accessed on 10 May 2013.

Catchment

A catchment is an area of land that is drained by a river and its tributaries. Delineation can be made based on the topographic divide (watershed) using digital terrain models (DTM). DTMs are freely available online from a variety of sources, such as the 30 m resolution ASTER GDEM from NASA and Japan Space Systems (http://asterweb.jpl.nasa.gov/gdem.asp).

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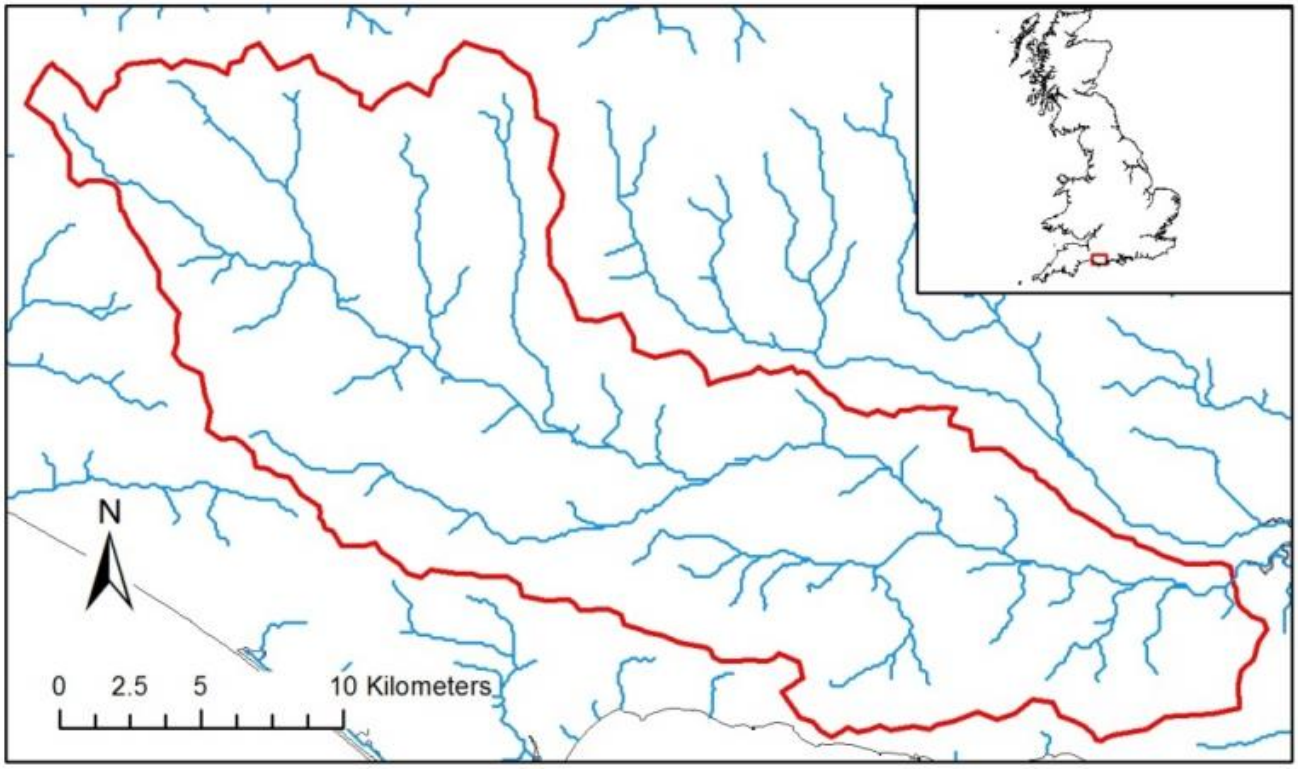
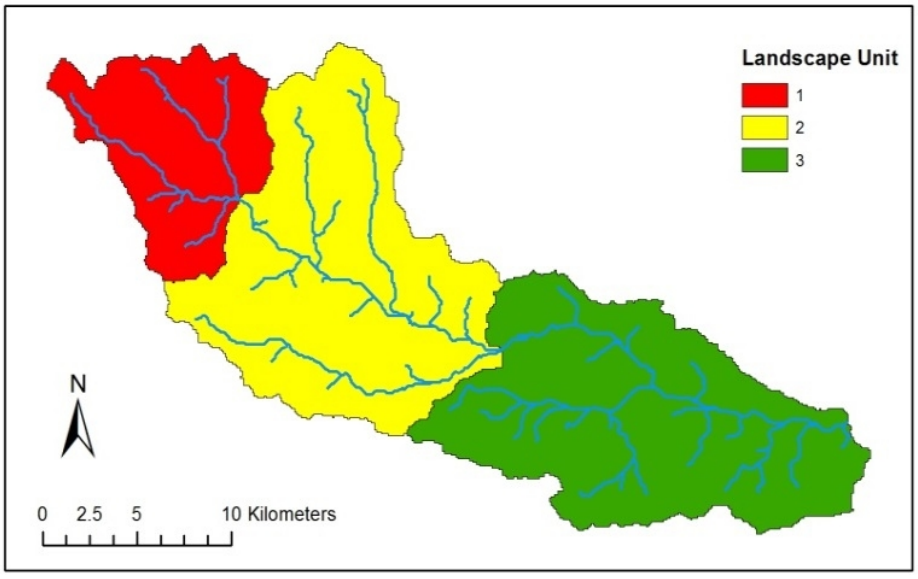


The Frome catchment was delineated using a 10m resolution DTM and the Hydrology toolset in ArcGIS 10.0. It is a medium-sized, lowland, calcareous catchment according to the Water Framework Directive typology (catchment area = 457 km^2, median elevation = 104 m). Profile DTM: © Crown Copyright/database right 2012. Image: Robert Grabowski, QMUL.

Landscape units

Landscape units are portions of the catchment with similar morphological characteristics. The catchment is divided into landscape units that are broadly consistent in terms of their topography, geology and land cover, as these factors determine the hydrological responsiveness of a catchment and the source and delivery of sediment to the river system.



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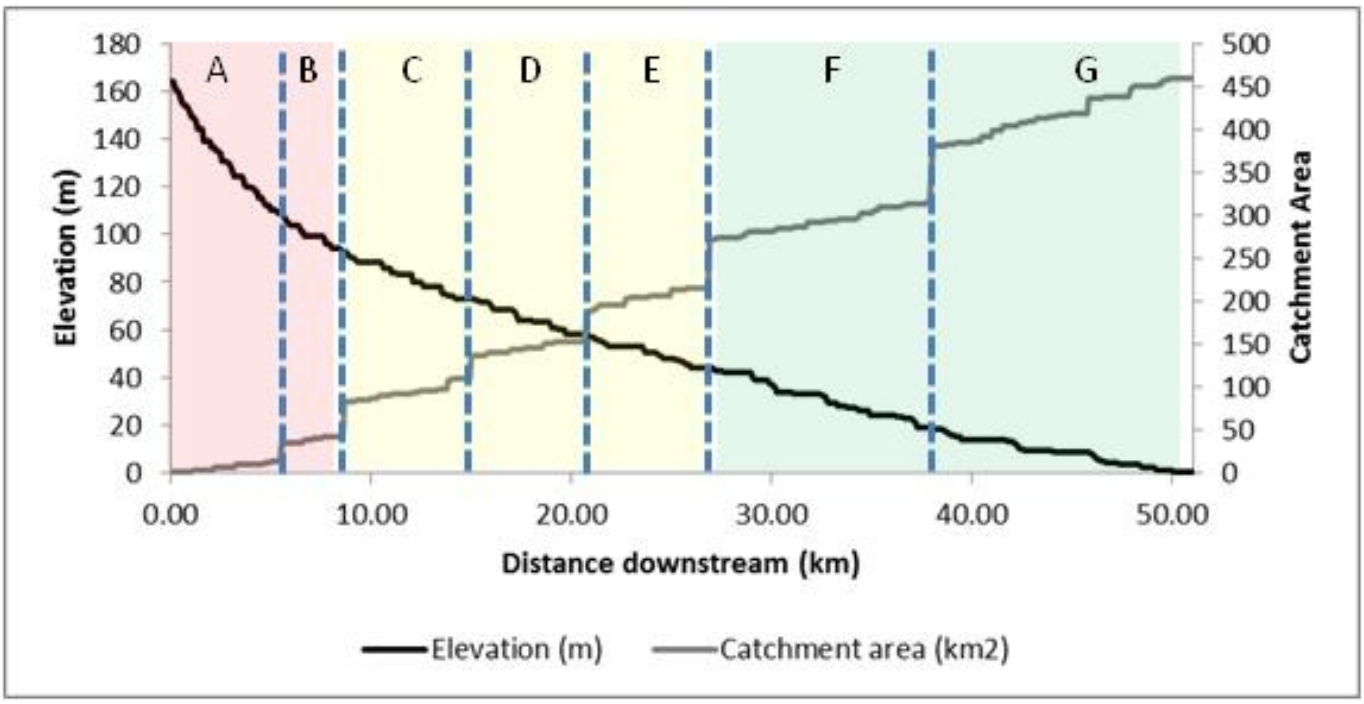
	1	2	3
Area (km²)	83	189	186
Elevation (m)			
< 200	78%	91%	100%
200 - 800	22%	9%	0%
Gradient	0.0088	0.0031	0.0021
Geology	Calcareous	Calcareous	Siliceous
Land Cover	Pasture	Arable Land	Arable Land

The Frome catchment was delineated into 3 landscape units based on elevation, geology and land cover. Data analysis was conducted in ArcGIS using datasets obtained from the UK Environment Agency (elevation and gradient), onegeology.org (geology; freely available), and the European Commission's Joint Research Centre (Corinne land cover; freely available). Profile DTM: © Crown Copyright/database right 2012. Images: Robert Grabowski, QMUL.

River segments

River segments are sections of the river network that are subjected to similar valley-scale influences and energy conditions. Delineation is based on major changes in valley gradient, major tributary confluences, and valley confinement.



The River Frome is delineated into 7 river segments (A-G), separated by dashed blue lines in the above graph. These divisions are primarily associated with significant increases in catchment area (grey line) due to major tributary confluences and align with the landscape unit divisions. The long profile was extracted from the DTM and the flow accumulation layer generated by ArcGIS during the watershed delineation process. Profile DTM: © Crown Copyright/database right 2012. Image: Robert Grabowski, QMUL.

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River reaches

The reach is the scale at which most people view and interact with the river, and the scale at which most restoration projects are focused. Hydromorphologically speaking, it is a section of river along which boundary conditions are sufficiently uniform that the river maintains a near consistent set of process-form interactions. In other words, the controlling factors that we identified in the earlier delineation steps produce characteristic patterns and landforms in the channel and floodplain, like river meanders and gravel bars. Delineation is based primarily on channel planform and confinement and results in a simple classification of river types.

Landscape unit	Segment	Reach	Confinement	Threads	Planform
1	A	1	Unconfined	Single	Sinuous
	B	2	Unconfined	Single	Sinuous
		3	Unconfined	Single	Meandering
		4	Partially confined	Single	Sinuous
2	C	5	Unconfined	Single	Sinuous
	D	6	Unconfined	Single	Sinuous
		7	Unconfined	Multi-thread	Anabranching
	E	8	Unconfined	Multi-thread	Anabranching
		9	Unconfined	Multi-thread	Anabranching
3	F	10	Unconfined	Multi-thread	Anabranching
		11	Unconfined	Multi-thread	Anabranching
		12	Unconfined	Multi-thread	Anabranching
	G	13	Unconfined	Multi-thread	Anabranching
		14	Unconfined	Single	Meandering
		15	Unconfined	Single	Meandering

The River Frome is subdivided into 15 river reaches using satellite imagery from Google Earth and large-scale maps from the UK's Ordnance Survey. At first instance, reach divisions align with landscape and segment divisions. Further divisions are made when there are changes in valley confinement, the number of threads or channel planform within a segment, for example reaches 2-4 in segment B, or because of the presence of major weirs that disrupt water and sediment transfer, for example reaches 10-12 in segment F.

Next steps

Now that the river has been delineated into spatial units, the next step is to characterise the spatial units to more fully describe the hydromorphological processes at work. With this detailed information at hand, we are then able to assign an extended river typology and apply a suite of indicators to assess current hydromorphological condition.

Reference

European Environment Agency. 2002. Europe's biodiversity - biogeographical regions and seas, EEA Report No 1/2002. http://www.eea.europa.eu/publications/report_2002_0524_154909, accessed on 9 May 2013.

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