

UK TECHNICAL ADVISORY GROUP ON THE WATER FRAMEWORK DIRECTIVE

Type Specific Reference Condition Descriptions for Rivers in Great Britain

This Guidance Paper is a working draft defined by the UKTAG. It documents the principles to be adopted by agencies responsible for implementing the Water Framework Directive (WFD) in the UK. This method will evolve as it is tested, with this working draft amended accordingly.

Working Paper Version:	GB River Types_16.06.04 – without scotland maps + photos	Status:	Public Working Draft (PR 01)
WFD Requirement:	Article 5, Rivers, reference conditions	UKTAG Review:	6 June 2004
		Author:	RTT

1. Purpose of this Paper

The paper sets out UKTAG's guidance outlining the **type specific reference condition descriptions for rivers**.

2. The Directive's requirements

Under Annex II of the Directive, reference condition for each type of surface water body need to be developed.

This guidance was produced by the Rivers Task Team in consultation with other UKTAG Task Teams.

3. Content of this Guidance

The guidance contains:

- an outline of the approach to developing reference conditions (refer section 4)
- the type descriptions (refer section 5)

4. Approach to developing the type specific reference conditions

Type specific reference condition descriptions have been developed for inclusion in Article 5 report. General descriptions are provided for 18 river types covering Great Britain Ecoregion river types and contain:

- Type Overview description
- Reference Condition Quality Elements description/s.

5. Description of Type Specific Reference Conditions

River Type 1:

small catchment area (10-100km²), mean catchment altitude- low (<200m), with a predominantly siliceous geology.

Type overview: in England and Wales, this type of river is predominantly found in the South West (particularly Cornwall), Kent/Sussex, around the New Forest in Hampshire, West Wales, Anglesey and in the Lake District. In Scotland, it is found mainly in the Western Isles, Aberdeen-shire, the coastal fringes of the far Northwest, the South West and parts of the West. Across GB it covers 11% of the typed river length.

Macrophytes and phytobenthos: These streams combine many of the commoner elements of their mid altitude equivalent with species typically associated with more fertile lowland streams. Small channel sizes and unstable flows mean that marginal species often dominate.

Typically around 30 taxa occur in a 1km reach. The large emergent species are represented mainly by *Phalaris arundinacea* and to a lesser extent *Sparganium erectum* and *Oenanthe crocata*. Elsewhere banks are often lined by *Juncus effusus* or *J. acutiflorus*. Small marginal species are widespread, the most typical being the grasses *Agrostis stolonifera*, *Glyceria fluitans* plus *Caltha palustris*, *Mentha aquatica*, *Myosotis stolonifera*, *Veronica beccabunga*, *Juncus articulatus* and *Ranunculus flammula*. In terms of bryophytes *Fontinalis antipyretica*, *Rhynchostegium ripariodes*, *Pellia epiphylla* and *Conocephalum conicum* all occur at more than half the sites often in association with smaller quantities of other species such as *Chiloscyphus polyanthus*, *Fontinalis squamosa*, *Amblystegium* spp, *Thamnobryum alopecurum*, *Brachythecium rivulare* and *Racomitrium aciculare*. Filamentous algae are also common and widespread but do not dominate. Among the less frequent (15-25% of sites) but locally abundant species are several vascular aquatic species including *Rorippa*, *Nasturtium aquaticum*, *Callitriche* spp (including *C. stagnalis* and *C. hamulata*), *Myriophyllum alterniflorum*, *Juncus bulbosus*, *Sparganium emersum*, *Ranunculus penicillatus pseudofluitans*, *Lemna minor*, together with *Scapania undulata*, *Lemanea fluviatilis* and *Hildenbrandia rivularis*.

Epilithic diatom biofilms are dominated by *Achnantheidium* and *Eunotia* spp. The proportion of *Eunotia* will increase as acidity increases. Other taxa tolerant of acid conditions or occasional acidic episodes that might be found include *Peronia fibula*, *Tabellaria flocculosa*, *Brachysira vitrea*, *Frustulia* sp and *Psammothidium helveticum*.

Fish: In Scotland this lowland type commonly supports a range of species including brown trout, Atlantic salmon, 3 spine stickleback, stone loach, minnows, eels, lampreys (river and/or brook) and occasionally pike. North of the Highland Boundary Fault species diversity declines with reference condition populations often being restricted to brown trout, eels, Atlantic salmon, and on occasion sticklebacks.

In Wales the North, West and South West of England, brown trout are found in the upper reaches together with bullhead, minnow and brook lamprey. Where there are no natural barriers to migratory fish, salmon and/or sea trout and eel are to be expected together with river and/or sea lamprey. In the middle reaches stone loach will also occur together with grayling. Towards the east and south of England in the middle and lower reaches, chub and dace are likely to predominate rather than trout, and are often associated with gudgeon, pike, and possibly perch, roach and/or barbel. Where proximate to transitional waters across GB, some fish species associated with that habitat e.g. flounder, may occasionally be found.

Macroinvertebrates: the fauna of this type is diverse, with a good complement of mayfly, stonefly and caddis larvae. Significant regional variations in composition and diversity are likely to occur across Great Britain; however, Hydrobiidae, Oligochaeta, Gammaridae, Baetidae, Elmidae, Sericostomatidae, Chironomidae and Simuliidae are almost always present. Ancyliidae, Sphaeriidae, Heptageniidae, Leuctridae, Rhyacophilidae, Hydropsychidae, Limnephilidae, Leptoceridae occur frequently. Although less widely distributed, this type also includes river sites where the caddis Odontoceridae and dragonflies, Libellulidae and Cordulegasteridae are found.

Physico-chemistry: water colour will generally be clear, although it may be coloured by suspended material during periods of high flow. Alkalinities are generally low and pH is typically between 6-7. In the northern examples of the type pH values <6 may occur. River productivity is likely to be higher in southern examples of the type.

Hydrology: Siliceous catchments are likely to have a low baseflow index. The hydrological regime will thus have a low degree of connectivity with groundwater and exhibit a rapid hydrological response to rainfall events. Catchments at low elevations tend to receive less rainfall, and are therefore expected to show smaller discharges per unit catchment area. Smaller catchments show a quick hydrological response to rainfall, so the hydrograph time-to-peak and recession to baseflow will be relatively rapid.

Morphology: Mostly small streams and rivers with a range of slopes, resulting in a diversity of substrate types, that are related to flow velocity. Pebbles and cobbles tend to dominate in

faster flowing reaches, but more depositional environments with gravel, sand and silt may occur in the downstream sections.

River Type 2:

small catchment area (10-100km²), mean catchment altitude- low (<200m), with a predominantly calcareous geology.

Type overview: In England and Wales, this river type is found in virtually all lowland regions. It is the most common type covering 26% of typed river length across GB. In Scotland it is less abundant, with its distribution being restricted to the central belt, the Moray Firth, Caithness, Orkney and the borders.

Macrophytes and phytobenthos: These streams have many of the characteristics of Type 1 with an increased emphasis on species typical of more base- and nutrient-rich situations and are correspondingly slightly more species rich (c.35 species per 1km reach). Amongst the larger emergent species *Phalaris arundinacea* and *Sparganium erectum* are almost ubiquitous while *Epilobium hirsutum*, *Oenanthe crocata* and more rarely *Iris pseudacorus*, *Glyceria maxima*, *Schoenoplectus lacustris* and *Carex acutiformis* are less frequent but often abundant. Few rooted aquatic species are widespread except *Callitriche* spp and *Apium nodiflorum*, which occur in more than a third of sites, but several species including *Myriophyllum spicatum*, *Ranunculus penicillatus pseudofluitans*, *Potamogeton crispus*, *P. natans* and *Nuphar lutea* are regularly locally abundant. Amongst the bryophytes only *Fontinalis antipyretica* occurs in more than half the sites but *Rhynchostegium ripariodes*, *Amblystegium riparium*, *Conocephalum conicum* and *Pellia endiviifolia* are all widespread and common with *Hildenbrandia* a frequent associate. Other less frequently encountered bryophytes include *Chiloscyphus polyanthus*, *Cinclidotus fontinaloides* and *Pellia epiphylla*.

Epilithic diatom biofilms are dominated by *Achnanthydium minutissimum* and *Cocconeis placentula* along with other pollution-sensitive taxa. *Cladophora glomerata* will be either absent or form only a small part of the total photosynthetic biomass.

Fish: In Scotland, this lowland type supports a range of species including brown trout, Atlantic salmon 3 spined stickle back, stone loach, minnows, lampreys (brook and/or river) and occasionally pike. North of the Highland Boundary Fault diversity declines with reference condition populations in Orkney being restricted to brown trout and eels.

For rivers in Wales the North East, North West, South West and West of England brown trout commonly occur together with bullhead, minnow and brook lamprey. Where there are no natural barriers to migratory fish, salmon and/or sea trout and eel are to be expected together with river and or sea lamprey. In the middle reaches stone loach will also occur together with grayling. Towards the east and south of England, chub and dace are likely to predominate in the middle and lower reaches, together with gudgeon, pike, eel, ruffe and possibly perch, roach, spined loach and/or barbel. Where proximate to transitional waters across GB, some fish species associated with that habitat e.g. flounder, may occasionally be found.

Macroinvertebrates: the fauna will be diverse with a good complement of molluscs, mayflies and caddis that thrive in calcareous conditions. Significant regional variations in composition and diversity are likely to occur across Great Britain; however, Hydrobiidae, Sphaeriidae, Oligochaeta, Gammaridae, Baetidae, Elmidae and Chironomidae are almost always present, while Ancyliidae, Glossiphoniidae, Hydropsychidae, Tipulidae and Simuliidae occur frequently. Although less widely distributed, this type includes sites where Culicidae, Hirudidae, Libellulidae, Veliidae and Sisyridae may be present.

Physico-chemistry: water colour will generally be clear, although may be discoloured due to resuspension of deposited material during periods of high flow. Alkalinities are medium to high, and pH is typically 7 or higher. Natural levels of productivity are generally high.

Hydrology: Calcareous catchments are likely to have a high baseflow index. The hydrological regime will thus have a greater degree of connectivity with groundwater and

there will be a delayed and subdued hydrological response to rainfall events. Small catchments tend to show a quick hydrological response to rainfall, so the hydrograph time-to-peak and recession to baseflow will therefore be relatively rapid compared to larger calcareous catchments. Catchments at low elevations show smaller discharges per unit catchment area.

Morphology: These rivers cover a wide range of slope and flow velocity, resulting in a diversity of substrate types. In the upper reaches they may be relatively fast flowing with stony beds, while gravels, sands and silts will tend to be found in the less steep sections.

River Type 3:

small catchment area (10-100km²), mean catchment altitude- low (<200m), with predominantly organic surface deposits.

Type overview: in Scotland, this river type is typically found in parts of Caithness, the Western Isles, Skye, Orkney, Shetland and South West Scotland, while in England, it is restricted to streams draining into the Wash. In Scotland acidic conditions dominate, whereas in East Anglia base rich conditions prevail. It covers less than 2% of typed river length across GB.

Macrophytes and phytobenthos: Due to the lower gradients and greater extent of fine rooting medium rooted vascular plants are markedly more widespread in these streams which incorporate many of the shallow water elements of the flora of low alkalinity or peaty lakes. Characteristic aquatic species thus include *Juncus bulbosus* and *Myriophyllum alterniflorum* – both occurring in more than two thirds of examples – plus *Potamogeton polygonifolius*, *P. natans*, *Littorella uniflora*, *Callitriche hamulata* and *Eleogiton fluitans*. Less widespread species include *Sparganium emersum*, *S. angustifolium* and *Nuphar lutea*. In contrast to other similar stream types riverine bryophytes are rare with the exception of *Pellia epiphylla*, *Fontinalis antipyretica* and *Racomitrium aciculare* while the frequent presence of mire-forming species such as *Sphagnum* sp and *Calliergon cuspidatum* reflects the nature of adjacent peat forming habitats. Instead of *Phalaris arundinacea* the most typical large emergent species are *Carex rostrata* and *Equisetum fluviatile* but several other species such as *Iris pseudacorus*, *Sparganium erectum*, *Phragmites australis* and *Schoenoplectus lacustris* are also relatively widespread and locally abundant. Among the smaller emergent species *Ranunculus flammula*, *Carex nigra*, *Eleocharis palustris*, *Glyceria fluitans*, *Myosotis scorpioides*, *Hydrocotyle vulgaris*, *Galium palustre*, *Caltha palustris* and *Mentha aquatica* are the most typical. In sluggish reaches both *Menyanthes trifoliata* and *Potentilla palustris* can also be abundant. Richness is comparable to Type 1 streams (c. 30 species per reach).

Epilithic diatom biofilms are dominated by *Achnanthydium minutissimum* and *Cocconeis placentula* along with other pollution-sensitive taxa. *Cladophora glomerata* will be either absent or form only a small part of the total photosynthetic biomass.

Fish: The predominantly northerly distribution of this type in Scotland restricts its species composition to Atlantic salmon, brown trout, eel and on occasions 3 spine sticklebacks. The southern outliers will support additional species such as stone loach, river and brook lampreys, and on occasions pike.

In England, coarse fish and eels will dominate the fish population. Typical species will include eel, roach, bream, tench, perch, pike and 3 spined stickleback. Silver bream, ruffe, spined loach and rudd may also occur. Where proximate to transitional waters across GB, some fish species associated with that habitat e.g. flounder, may occasionally be found.

Macroinvertebrates: In Scotland the fauna will be impoverished in outer island examples where stoneflies and mayflies will be limited due geographical separation from the mainland. Otherwise, the fauna will be similar in composition to that of upland oligotrophic streams although abundance may be restricted. Mayfly species may include *Baetis rhodani* as well as *Ephemerella ignita*, *Rhithrogena semicolorata*, *Heptagenia lateralis*, *Ecdyonurus* spp and *Caenis rivulorum*. Stonefly species can include *Leuctra* spp., *Chloroperla torrentium*, *Amphinemura sulcicollis*, *Isoperla grammatica*, *Protonemura meyeri* and members of the

Perlidae and Perlodidae families. Caddis are likely to be well represented by members of the families Hydropsychidae, Philopotamidae, Polycentropidae, Rhyacophilidae, Limnephilidae and Hydroptilidae. In lowland English rivers, gastropods, water beetles and other taxa characteristic of slower flowing water are well represented. Hydrobiidae, Planorbidae, Sphaeriidae, Asellidae, Gammaridae, Dytiscidae, Leptoceridae and Chironomidae are likely to be very frequent, and Valvatidae, Oligochaeta, Glossiphoniidae, Erpobdellidae, Baetidae, Caenidae, Coenagrionidae, Notonectidae, Corixidae, Haliplidae may also occur.

Morphology: Small low altitude streams may be subject to peat deposition washed down in high flows such that the deeper slow flowing areas may be covered in fine particulate peat while faster flowing areas may have a sand or gravel substrate. Flows likely to be associated with runs and glides. In lowland England slopes are very low, and silt deposition is the dominant morphological process.

Hydrology: Organic catchments in Scotland are generally saturated, with a low baseflow index. They therefore exhibit a rapid response to rainfall events. England and Wales experience less rainfall at lower elevations, and here these rivers will be more dependent on groundwater inputs, with a less rapid response to rainfall. Catchments at lower elevations also show smaller discharges per unit catchment area. The hydrograph time-to-peak and recession to baseflow will be relatively rapid compared with larger catchments of similar type

Physico-chemistry: the water colour may be stained brown, which limits light penetration. In the rainfall dependent Scottish rivers pH is commonly < 6, although at times it will approach neutral, and alkalinity is very low. In the English examples of this type, more base-rich conditions are encountered.

River Type 4:

medium sized catchment area (100-1000 km²), mean catchment altitude- low (<200m), with a predominantly siliceous geology.

Type overview: in England and Wales this river type is found in hilly areas of the South, West and North. In Scotland, it occurs infrequently, and is found in restricted areas of the North coast, North East and South West. It covers less than 2% of the typed river length across GB.

Macrophytes and phytobenthos: There are many similarities with Type 1 streams but bryophytes are generally more frequent and extensive in these rivers, accounting for much of their species richness (average 32 species per reach) while emergent macrophytes are correspondingly more restricted reflecting the increase in channel size and extent of coarse substrates. The aquatic component is often dominated by bryophytes and macroalgae of which *Fontinalis antipyretica* and *Rhynchosygium riparioides* are almost ubiquitous. *Conocephalum conicum*, *Pellia epiphylla*, *Chiloscyphus polyanthos* and the lichen *Verrucaria* all occur in more than half the sites in this type while a further dozen taxa (including *Brachythecium* spp, *Amblystegium* spp, *Cinclidotus fontinaloides*, *Racomitrium aciculare* and *Scapania undulata*) feature in more than a fifth of sites, of which *Fontinalis squamosa*, *Lemanea fluviatilis* and *Hildenbrandia* are especially abundant. Green filamentous algae, mainly *Cladophora glomerata*, occur in more than half the sites and are often extensive in their coverage. Only four vascular aquatic plant species are at all frequent and abundant when present, namely *Myriophyllum alterniflorum*, *Ranunculus penicillatus penicillatus*, *Callitriche hamulata* and *C. stagnalis*. Marginal vegetation is comparatively restricted but invariably includes *Phalaris arundinacea* and *Oenanthe crocata*, and frequently *Sparganium erectum*, plus a suite of smaller species such as *Mentha aquatica*, *Myosotis scorpioides*, *Caltha palustris*, *Glyceria fluitans*, *Veronica beccabunga*, *Galium palustre*, *Juncus articulatus* and *Ranunculus flammula*.

Epilithic diatom biofilms are dominated by *Achnantheidium* and *Eunotia* spp. The proportion of *Eunotia* will increase as acidity increases. Other taxa tolerant of acid conditions or occasional acidic episodes that might be found include *Peronia fibula*, *Tabellaria flocculosa*, *Brachysira vitrea*, *Frustulia* sp and *Psammothidium helveticum*.

Fish: The predominantly northerly distribution of this type in Scotland restricts its species composition to Atlantic salmon, brown trout, eels and on occasions 3 spined stickle-backs. The southern outliers support additional species such as stone loach, lampreys (river, brook, and /or sea) and on occasions pike.

In England and Wales fish populations are likely to be dominated by brown trout together with bullhead, minnow and brook lamprey. Where there are no natural barriers to migratory fish, salmon and/or sea trout and eel are to be expected together with river and or sea lamprey. Stone loach may also occur together with dace and chub in Yorkshire and the South East. Where proximate to transitional waters across GB, some fish species associated with that habitat e.g. flounder, may occasionally be found.

Macroinvertebrates: the fauna will be diverse with a good complement of rithral taxa, particularly rich in caddis. Significant regional variations in composition and diversity are likely to occur across Great Britain, however Hydrobiidae, Ancyliidae, Oligochaeta, Gammaridae, Baetidae, Elmidae, Hydropsychidae, Leptoceridae, Tipulidae are almost always present. Sphaeriidae, Heptageniidae, Leuctridae, Rhyacophilidae, Lepidostomatidae, and Simuliidae occur frequently. Although less frequent, Tabanidae may also occur.

Morphology: Small rivers occurring on a range of slopes, though relatively shallow slopes predominate. Mostly cobble and gravel substrates.

Hydrology: Siliceous catchments are likely to have a low baseflow index. The hydrological regime will exhibit a relatively rapid hydrological response to rainfall events, but the larger upstream area of medium sized catchments moderates this response. This extends the hydrograph time-to-peak and slows the recession back to baseflow, compared with small catchments of similar geological type. Catchments at low elevations can be expected to show smaller discharges per unit catchment area.

Physico-chemistry: water colour will generally be clear, although may be coloured by suspended material during high flow periods. Productivity and alkalinity are generally low, and pH is typically between 6-7.

River Type 5:

medium size catchment area (100-1000 km²), mean catchment altitude- low altitude (<200m), with a predominantly calcareous geology

Type overview: in England and Wales, this type of river is widespread in all but the most upland areas. It is the third most common type and covers 12% of the typed river length across the GB. In Scotland it occurs infrequently and is confined mainly to the central belt, Orkney and small pockets in Eastern Scotland.

Macrophytes and phytobenthos: Due to more stable flows and substrate vascular plants dominate, cover is high and both aquatic and emergent vegetation is diverse with sites typically containing c. 45 species per reach. In terms of aquatic species shallow reaches dominated by coarse sand and gravel typically feature a mix of *Ranunculus penicillatus pseudofluitans*, *Berula erecta*, *Apium nodiflorum*, *Oenanthe fluviatilis*, *Fontinalis antipyretica* and *Callitriche* sp (especially *C. obtusangula*) bordered by *Rorippa nasturtium-aquaticum* and sometimes interspersed by beds of *Myriophyllum spicatum*, *Potamogeton crispus*, *P. pectinatus* or *Zannichellia palustris*. In the lower reaches of these rivers *Ranunculus fluitans* becomes increasingly dominant. In classic chalk streams *Hippuris vulgaris* and *Groenlandia densa* may also be present. In deeper, fine bedded, sluggish clay-based rivers most of the above species give way to a combination of *Nuphar lutea*, *Sparganium emersum*, *Schoenoplectus lacustris*, *Sagittaria sagittifolia*, *Butomus umbellatus*, *Lemna* spp, *Potamogeton perfoliatus*, *P. lucens* and occasionally *Ceratophyllum demersum*. In terms of the larger emergent species *Phalaris arundinacea* and *Sparganium erectum* are ubiquitous, very often in association with *Glyceria maxima*, *Epilobium hirsutum*, *Lythrum salicaria*, *Carex riparia* and *C. acutiformis*, and occasionally *Rumex hydrolapathum*. Numerous smaller species occur within this matrix or in more disturbed marginal areas of which *Myosotis scorpioides*, *Solanum dulcamara*, *Mentha aquatica*, *Veronica beccabunga*, *V. anagallis* –

aquatica, *Lycopus europaeus*, *Stachys palustris*, *Rorippa amphibia* and *Alisma plantago-aquatica* are the most typical.

Epilithic diatom biofilms are dominated by *Achnantheidium minutissimum* and *Cocconeis placentula* along with other pollution-sensitive taxa. *Cladophora glomerata* will be either absent or form only a small part of the total photosynthetic biomass.

Fish: In Scotland, this lowland type supports a range of species including brown trout, Atlantic salmon 3 spined stickle-back, stone loach, minnows, lamprey (river, brook, and/or sea), and occasionally pike. North of the Highland Boundary Fault diversity declines with reference condition populations in Orkney being restricted to brown trout and eels.

For rivers in Wales, the North East, North West, South West and West of England, brown trout commonly occur together with bullhead, minnow and brook lamprey. Where there are no natural barriers to migratory fish, salmon and/or sea trout and eel are to be expected together with river and or sea lamprey. In the middle reaches stone loach will also occur together with grayling. Towards the east and south of England in the middle and lower reaches, chub and dace are likely to predominate, together with gudgeon, pike, and possibly perch, roach and/or barbel. Where proximate to transitional waters across GB, some fish species associated with that habitat e.g. flounder, may occasionally be found.

Macroinvertebrates: the fauna will be diverse with a good complement of taxa characteristic of base-rich waters. Significant regional variations in composition and diversity are likely to occur across Great Britain however Hydrobiidae, Sphaeriidae, Oligochaeta, Glossiphoniidae, Gammaridae, Baetidae, Elmidae, Leptoceridae and Chironomidae are almost always present. Ancyliidae, Erpobdellidae, Asellidae, Caenidae, and Hydropsychidae are likely to be frequent. Although found less frequently, Neritidae, Unionidae, Hirudidae, Molannidae, Viviparidae, Valvatidae, Physidae, Platycnemididae, Coenagrionidae, Aeshnidae, Hydrometridae, Nepidae, Naucoridae, Aphelocheiridae, Notonectidae and Phryganeidae may occur.

Morphology: A widespread group, including many chalk streams, mostly occurring on shallow slopes. Channel width is variable, and there is a predominantly depositional environment, resulting in gravels and silts being the most common substrate type.

Hydrology: Calcareous catchments have a relatively high baseflow index. The hydrological regime will therefore exhibit a significant degree of connectivity with groundwater and as result there will be a delayed and subdued hydrological response to rainfall events. Catchments at lower elevations, with less rainfall, show smaller discharges per unit catchment area. The larger upstream area of medium sized catchment reduces the speed of the hydrological response to rainfall. This extends the hydrograph time-to-peak and slows the recession back to baseflow.

Physico-chemistry: water colour will generally be clear, although it may be discoloured due to resuspension of deposited material during periods of high flow. Alkalinity is typically medium to high, and pH is 7 or higher.

River Type 6:

medium size catchment area (100-1000 km²), mean catchment altitude- low (<200m), with a predominantly organic surface geology.

Type overview: This is a rare river type being restricted Caithness and the South West in Scotland, and the lowlands draining into the Wash in England, covering less than 1% of the typed river length across GB. In Scotland acidic conditions dominate, whereas in East Anglia base rich conditions prevail.

Macrophytes and phytobenthos: Due to the lower gradients and greater extent of fine rooting medium rooted vascular plants are markedly more widespread in these streams which incorporate many of the shallow water elements of the flora of low alkalinity or peaty lakes.

Characteristic aquatic species thus include *Juncus bulbosus* and *Myriophyllum alterniflorum* – both occurring in more than two thirds of examples – plus *Potamogeton polygonifolius*, *P. natans*, *Littorella uniflora*, *Callitriche hamulata* and *Eleogiton fluitans*. Less widespread species include *Sparganium emersum*, *S. angustifolium* and *Nuphar lutea*. In contrast to other similar stream types riverine bryophytes are rare with the exception of *Pellia epiphylla*, *Fontinalis antipyretica* and *Racomitrium aciculare* while the frequent presence of mire-forming species such as *Sphagnum* sp and *Calliergon cuspidatum* reflects the nature of adjacent habitats. Instead of *Phalaris arundinacea* the most typical large emergent species are *Carex rostrata* and *Equisetum fluviatile* but several other species such as *Iris pseudacorus*, *Sparganium erectum*, *Phragmites australis* and *Schoenoplectus lacustris* are also relatively widespread and locally abundant. Among the smaller emergent species *Ranunculus flammula*, *Carex nigra*, *Eleocharis palustris*, *Glyceria fluitans*, *Myosotis scorpioides*, *Hydrocotyle vulgaris*, *Galium palustre*, *Caltha palustris* and *Mentha aquatica* are the most typical. In sluggish reaches both *Menyanthes trifoliata* and *Potentilla palustris* can also be abundant. Richness is comparable to Type 1 streams (c. 30 species per reach).

Epilithic diatom biofilms are dominated by *Achnanthydium minutissimum* and *Cocconeis placentula* along with other pollution-sensitive taxa. *Cladophora glomerata* will be either absent or form only a small part of the total photosynthetic biomass.

Fish: The northern examples of this type in Scotland support a restricted species composition including Atlantic salmon, brown trout, eels and on occasions 3 spined stickle-backs. The southern examples may support additional species such as stone loach river, brook and sea lampreys, and on possibly pike.

In England coarse fish and eel will dominate the fish population. Typical species will include eel (where migration is possible), roach, bream, tench, perch, pike and 3 spined stickle-back. Silver bream, ruffe and rudd may also occur. Where proximate to transitional waters across GB, some fish species associated with that habitat e.g. flounder, may occasionally be found.

Macroinvertebrates: In Scotland the fauna will be similar in composition to that of upland oligotrophic streams although abundance may be restricted. Mayfly species may include *Baetis rhodani* as well as *Ephemerella ignita*, *Rhithrogena semicolorata*, *Heptagenia lateralis*, *Ecdyonurus* spp and *Caenis rivulorum*. Stoneflies may include *Leuctra* spp., *Chloroperla torrentium*, *Amphinemura sulcicollis*, *Isoperla grammatica*, *Protonemura meyeri* and members of the Perlidae and Perlodidae families. Caddis larvae are well represented by members of the families Hydropsychidae, Philopotamidae, Polycentropidae, Rhyacophilidae, Limnephilidae and Hydroptilidae. In England gastropods, water beetles and other taxa characteristic of slower flowing water are well represented e.g. Hydrobiidae, Planorbidae, Sphaeriidae, Oligochaeta, Glossiphoniidae, Erpobdellidae, Asellidae, Gammaridae, Baetidae, Coenagriidae, Haliplidae, Dytiscidae, and Chironomidae. Families with a frequent occurrence include Planorbidae, Valvatidae, Physidae, Piscicolidae, Notonectidae, Corixidae and Leptoceridae.

Morphology: generally mid to lower reaches of small to medium sized rivers. They are likely to be depositional in nature, with runs and riffles and substrates ranging from sand and gravel to cobbles and boulders. In England slopes are very low, and the substrate may be dominated by silt.

Hydrology: Organic catchments in Scotland are generally saturated, with a low baseflow index. They therefore exhibit a relatively rapid response to rainfall events. England and Wales experience less rainfall at lower elevations, and here these rivers will be more dependent on groundwater inputs, with a less rapid response to rainfall. The larger upstream area of medium sized catchment reduces the speed of the hydrological response to rainfall. This extends the hydrograph time-to-peak and slows the recession back to baseflow. Catchments at low elevations also show smaller discharges per unit catchment area. .

Physico-chemistry: the water may be stained brown, which limits light penetration. In the rainfall dependent Scottish rivers pH < 6 is common, although at times it may approach

neutral, and alkalinity is often very low. In the English examples of this type, more base-rich conditions are encountered.

River Type 7:

large catchment area (>1000 km²), mean catchment altitude- low (<200m), with a predominantly siliceous geology.

Type overview: This type occurs exclusively in England and Wales and is restricted to the Severn's midland catchment, covering less than 1% of typed river length in GB.

Macrophytes and phytobenthos: There are many similarities with Type 1 streams but bryophytes are generally more frequent and extensive in these rivers, accounting for much of their species richness (average 32 species per reach) while emergent macrophytes are correspondingly more restricted reflecting the increase in channel size and extent of coarse substrates. The aquatic component is often dominated by bryophytes and macroalgae of which *Fontinalis antipyretica* and *Rhynchostegium riparioides* are almost ubiquitous. *Conocephalum conicum*, *Pellia epiphylla*, *Chiloscyphus polyanthos* and the lichen *Verrucaria* all occur in more than half the sites in this type while a further dozen taxa (including *Brachythecium* spp, *Amblystegium* spp, *Cinclidotus fontinaloides*, *Racomitrium aciculare* and *Scapania undulata*) feature in more than a fifth of sites, of which *Fontinalis squamosa*, *Lemanea fluviatilis* and *Hildenbrandia* are especially abundant. Green filamentous algae, mainly *Cladophora glomerata*, occur in more than half the sites and are often extensive in their coverage. Only four vascular aquatic plant species are at all frequent and abundant when present, namely *Myriophyllum alterniflorum*, *Ranunculus penicillatus penicillatus*, *Callitriche hamulata* and *C. stagnalis*. Marginal vegetation is comparatively restricted but invariably includes *Phalaris arundinacea* and *Oenanthe crocata*, and frequently *Sparganium erectum*, plus a suite of smaller species such as *Mentha aquatica*, *Myosotis scorpioides*, *Caltha palustris*, *Glyceria fluitans*, *Veronica beccabunga*, *Galium palustre*, *Juncus articulatus*, and *Ranunculus flammula*.

Epilithic diatom biofilms are dominated by *Achnantheidium* and *Eunotia* spp. The proportion of *Eunotia* will increase as acidity increases. Other taxa tolerant of acid conditions or occasional acidic episodes that might be found include *Peronia fibula*, *Tabellaria flocculosa*, *Brachysira vitrea*, *Frustulia* sp and *Psammothidium helveticum*

Fish: The upstream sections of this type are likely to be dominated by salmonids whilst down stream sections more commonly support a mixture of coarse and salmonid species. Brown trout will occur in the upper reaches together with bullhead, minnow, brook lamprey, salmon and eel where there are no natural barriers to migration. In the middle reaches stone loach will also occur together with grayling and increased numbers of eel. Further downstream coarse fish such as chub, dace and bleak are likely to predominate together with gudgeon, roach, pike, perch, and ruffe. Eel, river and sea lamprey are also to be expected in the middle and lower reaches.

Macroinvertebrates: The fauna will be diverse with species of Ancyliidae, Sphaeriidae, Oligochaeta, Erpobdellidae, Gammaridae, Baetidae, Ephemeridae, Hydrophilidae, Hydraenidae, Elmidae, Hydropsychidae, Sericostomatidae, Tipulidae, Chironomidae and Simuliidae occurring on a frequent basis.

Morphology: This type occurs on mainly shallow slopes, with varying channel width. A wide range of substrates occur, with gravel and cobbles being the most common.

Hydrology: Siliceous catchments are likely to have a low baseflow index. The hydrological regime will exhibit a relatively rapid response to rainfall events, but the upstream area of large sized catchments moderates this response. This extends the hydrograph time-to-peak and slows the recession back to baseflow, compared with small and medium sized catchments of similar geological type. Catchments at low elevations will produce smaller discharges per unit catchment area.

Physico-chemistry: the water colour will be clear, although it may be coloured by suspended sediments at times of high flow. Alkalinity will be low, and pH is typically between 6-7.

River Type 8:

large catchment area (>1000 km²), mean catchment altitude- low (<200m), catchments with a predominantly calcareous geology

Type overview: This type occurs exclusively in England and Wales, and whilst it is widespread, it only covers 3% of the typed river length across GB.

Macrophytes and phytobenthos: There are many similarities with the composition of the vegetation of Type 5 rivers and species richness is typically very high (>c.45 species per reach). The main differences are in the increased emphasis on species characteristic of deep water, fine sediment microhabitats and the corresponding reduced frequency of some species more typical of shallow water, gravel bed habitats. Thus, species such as *Potamogeton perfoliatus*, *P. lucens*, *P. pectinatus*, *Sparganium emersum*, *Myriophyllum spicatum*, *Nuphar lutea* and *Ceratophyllum demersum* are commoner in Type 8 than Type 5 rivers, as are *Sagittaria sagittifolia* and *Butomus umbellatus* two emergent species with submerged or floating-leaved growth forms. Other less frequent but locally abundant species in this category include *P. berchtoldii*, *P. natans*, *P. nodosus* and *Ranunculus circinatus*. By contrast *Callitriche* spp (notably *C. obtusangula*) are distinctly scarcer, as are several shallow water instream plants such as *Berula erecta*, *Oenanthe fluviatilis* and *Veronica anagallis aquatica*, and marginal emergent species like *Carex acutiformis*. Although as frequent as in Type 5 rivers *Ranunculus fluitans* is typically less abundant than in Type 8 rivers.

Epilithic diatom biofilms are dominated by *Achnanthydium minutissimum* and *Cocconeis placentula* along with other pollution-sensitive taxa. *Cladophora glomerata* will be either absent or form only a small part of the total photosynthetic biomass.

Fish: The upstream sections of this type are dominated by salmonids whilst the middle sections more commonly support a mixture of coarse and salmonid species. Where there are no natural barriers to migratory fish, salmon and/or sea trout and eel will occur, with the exception of East Anglia Atlantic salmon are absent. In the middle reaches, chub and dace are likely to predominate, together with gudgeon, minnow, stone loach, pike, and possibly perch, roach and/or barbel, river and/or sea lamprey. Coarse fish dominate the lower reaches, with typical species including eel roach, bream, tench, perch, silver bream, bleak, ruffe, rudd, pike and 3 spined stickle-back.

Macroinvertebrates: the fauna will be diverse with a good complement of taxa characteristic of base-rich waters. Species of Hydrobiidae, Sphaeriidae, Oligochaeta, Asellidae, Gammaridae, Baetidae, Caenidae, Leptoceridae and Chironomidae are almost always present. Lymnaeidae, Planorbidae, Ancyliidae, Erpobdellidae, and Elmidae occur frequently. Species of Corophiidae, Viviparidae, Molannidae, Phryganaeidae, Aphelocheiridae, are found but occur less frequently.

Morphology: A widespread group including many chalk rivers. Channel slope tends to be relatively low, and flows will be slow in the lower reaches. Extensive meanders, with ox-bows and cut-off channels on the floodplains are likely. A diverse range of substrates occurs; with depositional processes dominating, resulting in sand and gravel and silt beds occurring frequently.

Hydrology: Calcareous catchments have a relatively high baseflow index. The hydrological regime will therefore exhibit a significant degree of connectivity with groundwater and as a result a delayed and subdued hydrological response to rainfall events. Catchments at lower elevations, with less rainfall, show smaller discharges per unit catchment area. The large upstream area results in an extended hydrological response to rainfall. This gives a long time-to-peak and a slow recession back to baseflow conditions.

Physico-chemistry: water colour will generally be clear, although it may be discoloured due to the resuspension of deposited material during periods of high flow. Natural productivity and alkalinity is medium to high, and pH is typically 7 or higher.

River Type 9:

large catchment area (>1000 km²), mean catchment altitude- low (<200m), with a predominantly organic surface geology.

Type overview: This type occurs exclusively in England and Wales, and is very restricted in its distribution covering less than 1% of the typed river length across GB.

In reference condition this river type would be expected to display biological characteristics similar to those of Type 6 rivers. With no channel modification, the river would be closely associated with floodplain wetlands, with extensive meanders, very slow flows, and a significant dependence on groundwater to maintain baseflow. Depositional processes would dominate the channel and surrounding floodplain, with extensive flooding into the wetlands occurring at time of high winter flows.

River Type 10:

small catchment area (10-100km²), mean catchment altitude- medium (200-800m), with a predominantly siliceous geology.

Type overview: This is the most common Scottish type occurring in the Highlands, Cairngorms, Grampians and Southern Uplands. In England and Wales, it is predominantly found in the West (Cornwall, North Devon, Wales, the Pennines and Cumbria). Across GB it is the second most common type covering 22% of typed rivers.

Macrophytes and phytobenthos: Vegetation is heavily dominated by bryophytes. The commonest instream species occurring in more than half the sites are *Pellia epiphylla*, *Racomitrium aciculare* and *Scapania undulata*. The larger patch forming mosses such as *Fontinalis* spp, *Brachythecium* spp, *Hygrohypnum ochraceum* and *Rhynchostegium riparioides*, and classic upland leafy liverworts such as *Jungermannia atrovirens*, *Marsupella emarginata* and *Nardia compressa* are all well represented. Due to the hydrological responsiveness of these streams the emergent rock and gravel habitat is often extensive and favours species such as *Schistidium alpicola* and *Dichodontium pellucidum*, while incoming flushes and waterfalls create additional areas of wet rock occupied by species such as *Hyocomium armoricum*, *Dicranella palustris* and *Philonotis fontana*. With the exception of *Juncus bulbosus* rooted aquatic vascular species are scarce although some lower gradient sections with patches of finer sediment may support *Myriophyllum alterniflorum*, *Potamogeton polygonifolius*, *Callitriche hamulata* or *Littorella uniflora*. Emergent vegetation is restricted to smaller species associated with periodically inundated blanket peat (e.g. *Juncus acutiflorus*, *Carex nigra*, *C. rostrata*, *Hydrocotyle vulgaris*, *Galium palustre*, *Caltha palustris*, *Ranunculus flammula*), flush zones (e.g. *Montia fontana*) or stabilised gravel bars (e.g. *Juncus articulatus*, *Equisetum arvense*). Cover and species richness of such sites is highly variable depending on slope and bed stability. Some high altitude, mobile gravel bed streams are almost unvegetated, while larger streams with extensive bedrock or boulders may support a comparatively diverse and extensive flora

Epilithic diatom biofilms are dominated by *Achnantheidium* and *Eunotia* spp. The proportion of *Eunotia* will increase as acidity increases. Other taxa tolerant of acid conditions or occasional acidic episodes that might be found include *Peronia fibula*, *Tabellaria flocculosa*, *Brachysira vitrea*, *Frustulia* sp and *Psammothidium helveticum*.

Fish: in Scotland, Atlantic salmon, brown trout, and eels commonly populate upper reach examples of this type where there is unrestricted access by migratory fish. Where natural barriers impede fish migration brown trout and eels can be found. It may be quite natural to find fishless sections of this type upstream of impassable water-falls. Further down stream these species can be found with 3 spined stickleback, stone loach, minnows, river, brook and/or sea lamprey, and possibly pike. In rivers north of the Great Glen species diversity is generally lower, with the non-salmonid species, except eels rarely being present. In England

and Wales fish populations are likely to be dominated by brown trout together with bullhead, minnow and brook lamprey. Stone loach may also occur. Where there are no natural barriers to migratory fish, salmon and/or sea trout and eel (nearer the sea) are found together with river and or sea lamprey. Where proximate to transitional waters across GB, some fish species associated with that habitat e.g. flounder, may occasionally be found.

Macroinvertebrates: the fauna will be diverse with a good complement of stonefly, mayfly and caddis species being present. Mayfly species may include *Baetis rhodani* as well as *Ephemera ignita*, *Rhithrogena semicolorata*, *Heptagenia lateralis*, *Ecdyonurus* spp and *Caenis rivulorum*. Stoneflies encountered may include *Leuctra* spp., *Chloroperla torrentium*, *Amphinemura sulcicollis*, *Isoperla grammatica*, *Protonemura meyeri* and members of the Perlidae and Perlodidae families. Caddis larvae are well represented by members of the families Hydropsychidae, Philopotamidae, Polycentropidae, Rhyacophilidae, Sericostomatidae, Limnephilidae and Hydroptilidae.

Morphology: This type is ubiquitous in upland areas typically supporting eroding habitats in the upper reaches and depositing habitats in the lower reaches. Flow types range from turbulent types in the upper reaches with runs, glides, riffles and pools occurring further downstream. Substrates may range from silt, sand and gravel to cobbles, boulders and bedrock.

Hydrology: Siliceous catchments are likely to have a low baseflow index. The hydrological regime will therefore have a lesser degree of connectivity with groundwater and exhibit a relatively rapid hydrological response to rainfall events. Rainfall is greater at higher elevations. Catchments at medium elevations can therefore be expected to show increased discharges per unit catchment area. Smaller catchments show a quick hydrological response to rainfall. The hydrograph time-to-peak and recession to baseflow will therefore be relatively speedy.

Physico-chemistry: water will generally be clear, although may be coloured by suspended material during high flow periods. Natural productivity and alkalinity is low, and pH typically between 6-7, although natural acid episodes can reduce levels to 5.

River Type 11:

small catchment area, (10-100 km²), mean catchment altitude- medium (200-800m), with a predominantly calcareous geology.

Type overview: in Scotland this type occupies the more elevated parts of central Scotland, the borders, Aberdeenshire, Skye, Mull and Arran. In England and Wales, it is moderately widespread but is predominantly located in northern areas and Wales covering 7% of typed river length across GB.

Macrophytes and phytobenthos: As with Type 10 the vegetation is dominated by bryophytes but species of base-rich or slightly more fertile habitats (e.g. *Fontinalis antipyretica*, *Rhynchostegium riparioides*, *Conocephalum conicum*, *Cinclidotus fontinaloides*, *Amblystegium* spp, *Hygrohypnum luridum*, *Pellia endiviifolia*) are relatively more important than those more typically associated with infertile siliceous substrates (e.g. *Racomitrium aciculare*, *Hygrohypnum ochraceum*, *Scapania undulata* and other leafy liverworts) and the vegetation as a whole is slightly more species rich (33 species per reach). The algae *Lemanea fluviatilis* and *Hildenbrandia* are markedly more common as are lichens such as *Verrucaria*. Rooted vascular species are scarce with the commonest, *Juncus bulbosus*, occurring at half its frequency in Type 10 streams with *Potamogeton crispus* instead growing alongside *Myriophyllum alterniflorum*. The emergent marginal flora is more diverse with species such as *Myosotis scorpioides*, *Veronica beccabunga*, *Eleocharis palustris*, *Sparganium erectum* *Phalaris arundinacea* and *Rorippa nasturtium aquaticum* all occurring at much higher frequencies than in Type 10 streams.

Epilithic diatom biofilms are dominated by *Achnanthydium* spp, along with other pollution-sensitive taxa such as *Meridion circualre*, *Hannaea arcus*, *Fragilaria capucina* (*sensu stricto*), several *Cymbella* spp and some *Gomphonema* spp. *Didymosphenia geminata*, *Achnanthes*

oblongella and *Psammothidium* spp are sometimes abundant. *Cladophora glomerata* will either be absent or form only a small part of the total photosynthetic biomass.

Fish: in Scotland, Atlantic salmon, brown trout, and eels commonly populate upper reach examples of this type where there is unrestricted access by migratory fish. Where natural barriers impede fish migration brown trout and eels can be found. It may be quite natural to find fishless sections of this type upstream of impassable water-falls. Further down stream these species can be found with 3 spined stickleback, stone loach, minnows, river, brook and/or sea lamprey, and possibly pike. In rivers north of the Great Glen species diversity is generally lower, with the non-salmonid species except eels rarely being present. In England and Wales fish populations are likely to be dominated by brown trout together with bullhead, minnow and brook lamprey. Stone loach may also occur. Where there are no natural barriers to migratory fish, salmon and/or sea trout and eel are to be expected together with river and or sea lamprey.

Macro-invertebrates: this river type will generally be more productive than the equivalent organic or siliceous types. The fauna will be diverse with a good complement of rithral taxa including stoneflies, the commonness of which reflects the fact that this type includes what are generally considered in England and Wales to be circum-neutral to moderately base poor as well as calcareous rivers. Significant regional variations in composition and diversity are likely to occur across Great Britain, however Oligochaeta, Gammaridae, Baetidae, Heptageniidae, Leuctridae, Elmidae, Rhyacophilidae, Hydropsychidae, Tipulidae, and Chironomidae are almost always present. Nemouridae, Perlodidae, Sericostomatidae, and Simuliidae are frequent. Although found less frequently, Acroloxidae, Crangonyctidae, Capniidae and Perlidae may occur.

Many of the species associated with base-poor rivers will be present with a few exceptions. *Rhithrogena semicolorata* while present may be restricted to the upper faster flowing stretches as will be the case with stoneflies. In the faster stretches, *Leuctra* are likely to be abundant while species such as *Perloides microcephala* and *Brachyptera risi* may well be absent. The pearl mussel, *Margaritifera* may be replaced by *Unio* spp and *Anodonta* species. Examples with increased alkalinity will tend to support a greater abundance and diversity of molluscs.

Morphology: small to medium size rivers. The flow will vary from being turbulent and fairly fast in places to slow in others, while the substrate can range from fine sand and silt to gravel or cobbles. This type will have riffles, runs and some pools associated with it, the slower flowing downstream sections being largely depositional while the more turbulent upper sections will be erosional.

Hydrology: Calcareous catchments are likely to have a high baseflow index. The hydrological regime will thus have a greater degree of connectivity with groundwater and exhibit a delayed and subdued hydrological response to rainfall events. Greater rainfall is experienced at higher elevations. Catchments at higher elevations can therefore be expected to show increased discharges per unit catchment area. Small catchments tend to show a quick hydrological response to rainfall, so the hydrograph time-to-peak and recession to baseflow will therefore be rapid compared to larger calcareous catchments.

Physico-chemistry: water colour will generally be clear, although it may be discoloured due to resuspension of deposited material during periods of high flow. Alkalinity and natural productivity are medium to high, and pH is typically 7 or higher.

River Type 12:

small catchment area (10-100km²), mean catchment altitude- medium (200-800m) with a predominantly organic surface geology.

Type overview: This is an uncommon type being found in the North East Highlands, parts of the Cairngorms, and South West Scotland. In England and Wales, it is found mainly in the Pennines, and covers 2% of the typed river length across GB.

Macrophytes and phytobenthos: There are similarities with types 3, 6 and 9 but vegetation cover tends to be sparser and due to the increased relative importance of bryophytes species richness is somewhat higher (c. 35 species per reach). Both *Juncus bulbosus* and *Myriophyllum alterniflorum* are widespread (more than half the sites) and often abundant but the other main aquatic vascular species (*Callitriche hamulata*, *Potamogeton polygonifolius*, *P. natans*, *Littorella uniflora*, *Sparganium angustifolium*) are more restricted in their occurrence. The most typical instream bryophytes are *Pellia epiphylla*, *Racomitrium aciculare*, *Brachythecium plumosum*, *Rhynchostegium riparioides*, *Scapania undulata* and *Hygrohypnum luridum* while mire forming species such as *Sphagnum* and *Calliergon cuspidatum* dominate marginal habitats. The commonest large emergent species are *Carex rostrata*, *Equisetum fluviatile* and *Phalaris arundinacea* which occur in association with various smaller marginal species such as *Galium palustre*, *Ranunculus flammula*, *Hydrocotyle vulgaris*, *Caltha palustris*, *Montia fontana*, *Mentha aquatica* and *Carex nigra*.

Epilithic diatom biofilms are dominated by *Achnantheidium* and *Eunotia* spp. The proportion of *Eunotia* will increase as acidity increases. Other taxa tolerant of acid conditions or occasional acidic episodes that might be found include *Peronia fibula*, *Tabellaria flocculosa*, *Brachysira vitrea*, *Frustulia* sp and *Psammothidium helveticum*.

Fish: in Scotland, Atlantic salmon, brown trout, and eels commonly populate upper reach examples of this type with unrestricted access to migratory fish. Where natural barriers impede salmonid migration brown trout and eels will be found. It may be quite natural to find fishless sections of this type upstream of impassable water-falls. Further down stream these species will occur with 3 spined stickleback, stone loach, minnows, river and/or brook lamprey, and possibly pike. In rivers north of the Great Glen species diversity is generally lower, being restricted to salmonid species and eels. In England and Wales the fish populations are similar to the Scottish examples, with the addition of bullheads in some locations.

Macroinvertebrates: the fauna will be impoverished in outer island examples where stoneflies and mayflies will be limited due to the geographical separation. Otherwise, fauna will be similar in composition to that of oligotrophic streams although may be more sparse in numbers. Mayfly species may include *Baetis rhodani* as well as *Ephemerella ignita*, *Rhithrogena semicolorata*, *Heptagenia lateralis*, *Ecdyonurus* spp and *Caenis rivulorum*. Stoneflies may include *Leuctra* spp., *Chloroperla torrentium*, *Amphinemura sulcicollis*, *Isoperla grammatica*, *Protonemura meyeri* and members of the Perlidae and Perlodidae families. Caddis larvae are well represented by members of the families Hydropsychidae, Philopotamidae, Polycentropidae, Rhyacophilidae, Limnephilidae and Hydroptilidae.

Morphology: small to medium size, medium altitude rivers flowing through peat dominated landscapes. Lower reaches will be subject to peat deposition washed down in high flows such that the deeper slow flowing areas may be covered in fine particulate peat while faster flowing areas may have a sand or gravel substrate. In England and Wales cobble substrates may occur. Upper reaches will be erosional in nature.

Hydrology: Organic catchments are generally saturated, with a low baseflow index. They therefore exhibit a rapid response to rainfall events. Greater rainfall is experienced at higher elevations. Catchments at medium elevations can therefore be expected to show increased discharges per unit catchment area. Smaller catchments show a quick hydrological response to rainfall. The hydrograph time-to-peak and recession to baseflow will therefore be relatively rapid.

Physico-chemistry: water colour may be stained brown, which limits light penetration. Alkalinity is generally very low, and pH is typically < 6, although at times it will approach neutral.

River Type 13:

medium sized catchment area (100-1000km²), mean catchment altitude- medium (200-800m), with predominantly siliceous geology.

Type overview: In Scotland this common type is found throughout the Highlands, Cairngorms, Grampians and Southern Uplands. In England and Wales, it is predominantly found in the West (Cornwall, North Devon, Wales, the Pennines and Cumbria), covering 8% of the typed river length across GB.

Macrophytes and phytobenthos: The vegetation is clearly intermediate between Types 10 and 16 and due to the combination of steep gradient classic upland species and shallower gradient species in the vicinity of intact floodplain wetlands richness can be very high (40-45 species per site). *Myriophyllum alterniflorum*, *Callitriche hamulata* and *Juncus bulbosus* are the major rooted aquatic species, all many times more frequent in this type than in Type 14, with *Littorella uniflora*, *Potamogeton natans*, *P. polygonifolius* and *Ranunculus penicillatus* less widespread but occasionally relatively abundant. Among bryophytes *Rhynchostegium riparioides*, *Fontinalis antipyretica*, *F. squamosa*, *Hygrophyllum ochraceum*, *Pellia epiphylla* and *Chiloscyphus polyanthos* all occur in more than two thirds of the sites, while *Brachythecium* spp, *Dichodontium pellucidum*, *Racomitrium aciculare*, *Cinclidotus fontinaloides*, *Thamnobryum alopecurum*, *Schistidium alpicola*, *Amblystegium fluviatile* and *Scapania undulata* all occur in more than a third of sites usually with other lower plants such as *Lemanea* and the lichens *Verrucaria* spp and *Dermatocarpon fluviatile*. Species of the splash zone such as *Hyocomium armoricum* and *Marsupella emarginata* are markedly scarcer than in Type 10 rivers reflecting the general reduction in gradient. In terms of emergent species *Phalaris arundinacea* and *Juncus effusus* are almost ubiquitous while in low gradient reaches with sheltered margins *Carex rostrata*, *C. aquatilis*, *Sparganium erectum*, *Iris pseudacorus* and *Equisetum fluviatile* may be locally abundant. *Mentha aquatica*, *Myosotis scorpioides*, *Eleocharis palustris*, and the usual suite of other small marginal species characteristic of base-poor rivers (*Ranunculus flammula*, *Carex nigra*, *Galium palustre*, *Caltha palustris*, *Montia fontana*) are all widespread.

Epilithic diatom biofilms are dominated by *Achnantheidium* and *Eunotia* spp, with the proportion of *Eunotia* increasing with increasing acidity. Other taxa tolerant of acid conditions or occasional acidic episodes that might be found include *Peronia fibula*, *Tabellaria flocculosa*, *Brachysira vitrea*, *Frustulia* sp and *Psammothidium helveticum*

Fish: in Scotland, Atlantic salmon, brown trout, and eels commonly populate upper reach examples of this type with unrestricted access to migratory fish. Where natural barriers impede fish migration brown trout and eels can be found. Further down stream these species can be found with 3 spined stickleback, stone loach, minnows, river, brook and/or sea lamprey, and possibly pike. In England and Wales fish populations are likely to be dominated by brown trout together with bullhead, minnow and brook lamprey. Stone loach may also occur. Where there are no natural barriers to migratory fish, salmon and/or sea trout and eel are to be expected together with river and or sea lamprey.

Macroinvertebrates: The fauna of this type is diverse with species of mayfly, stonefly leeches and simuliids commonly occurring. Mayfly species may include *Baetis rhodani* as well as *Ephemerella ignita*, *Rhithrogena semicolorata*, *Heptagenia lateralis*, *Ecdyonurus* spp and *Caenis rivulorum*. Stoneflies encountered may include *Leuctra* spp., *Chloroperla torrentium*, *Amphinemura sulcicollis*, *Isoperla grammatica*, *Protonemura meyeri* and members of the Perlidae and Perlodidae families. Caddis larvae are well represented by members of the families Hydropsychidae, Philopotamidae, Polycentropidae, Rhyacophilidae, Limnephilidae and Hydroptilidae, Lepidostomatidae, and Sericostomatidae.

Morphology: This type generally includes lower and middle reaches of medium sized rivers, in upland areas. In these areas there will be eroding and depositing zones with runs, riffles, and pools all being present. A range of substrate types are commonly found including sand, gravel, cobbles and boulders.

Hydrology: Siliceous catchments are likely to have a low baseflow index. The hydrological regime is therefore likely to have a low degree of connectivity with groundwater and exhibit a relatively rapid hydrological response to rainfall events. Increased rainfall is experienced at medium elevations, so these catchments will show increased discharges per unit catchment

area. However the larger upstream area of medium sized catchment reduces the speed of the hydrological response to rainfall. This extends the hydrograph time-to-peak and slows the recession back to baseflow.

Physico-chemistry: watercolour will usually be clear, although it may be coloured during spate periods. Alkalinity is generally low, and pH is typically 6-7.

River Type 14:

medium sized catchment area (100-1000 km²), mean catchment altitude- medium (200-800m), with a predominantly calcareous geology.

Type overview: This type is rare across GB being predominantly restricted to the northern parts of England and Wales, and the lowland areas of central Scotland and the borders, covering 3% of the typed river length across GB.

Macrophytes and phytobenthos: Generally there are many similarities with Type 11 and bryophytes are much less dominant than in Type 13 rivers and species richness is correspondingly a little lower (typically 35-40 species per site). Of the rooted aquatic species of Type 13 rivers only *Myriophyllum alterniflorum* occurs in more than a quarter of Type 14 rivers with species such as *Potamogeton crispus*, and to a lesser extent *Ranunculus penicillatus pseudofluitans*, being in much greater evidence. All the classic base-poor, upland bryophytes are much scarcer with other lower plant species such as *Conocephalum conicum*, *Amblystegium* spp, *Cinclidotus fontinaloides*, *Hildenbrandia* and the filamentous algae *Cladophora* and *Vaucheria* being relatively more common. Among the main emergent species *Phalaris arundinacea* is still the most widespread, but *Sparganium erectum* is considerably more common than in Type 13, and is joined by *Epilobium hirsutum*. The usual suite of small marginal or shallow water species are widespread, but most notably those of more fertile, base-rich situations such as *Veronica beccabunga*, *Solanum dulcamara*, *Rorippa sylvestris*, *Stachys palustris*, *Rorippa nasturtium-aquaticum* and *Persicaria amphibia*.

Epilithic diatom biofilms are dominated by *Achnantheidium* spp, along with other pollution-sensitive taxa such as *Meridion circualre*, *Hannaea arcus*, *Fragilaria capucina (sensu stricto)*, several *Cymbella* spp and some *Gomphonema* spp. *Didymosphenia geminata*, *Achnanthes oblongella* and *Psammothidium* spp are sometimes abundant. *Cladophora glomerata* will either be absent or form only a small part of the total photosynthetic biomass.

Fish: The fish communities in Scotland typically include Atlantic salmon, brown trout, minnow, stone loach, 3- spined stickleback, river & sea lampreys and possibly pike. Areas with lower current velocities will be characterised by the non-salmonid species. In England and Wales fish populations are likely to be dominated by brown trout together with bullhead, minnow and brook lamprey, although stone loach chub, dace and grayling may also occur. Where there are no natural barriers to migratory fish, salmon and/or sea trout and eel (typically at sites not too far from the sea) are to be expected together with river and/or sea lamprey.

Macroinvertebrates: the fauna will be diverse with a good complement of rithral taxa including stoneflies. The fauna reflects the fact that this type includes what are generally considered to be circum-neutral to moderately base poor, as well as truly calcareous, rivers. Significant regional variations in composition and diversity are likely to occur across Great Britain, however Hydrobiidae, Oligochaeta, Gammaridae, Baetidae, Heptageniidae, Elmidae, Rhyacophilidae, Hydropsychidae, Tipulidae, Chironomidae and Simuliidae are almost always present and Leuctridae and Perlodidae are frequent.

Morphology: A widespread group, mostly occurring on relatively shallow slopes. Substrates are mostly coarse in nature, and likely to include pebble or gravel.

Hydrology: Calcareous catchments are likely to have a high baseflow index. The hydrological regime will therefore exhibit a greater degree of connectivity with groundwater and a delayed and subdued hydrological response to rainfall events. Increased rainfall is experienced at medium elevations, so these rivers can therefore be expected to show increased discharges per unit catchment area. The larger upstream area of medium sized

catchment further reduces the speed of the hydrological response to rainfall. This extends the hydrograph time-to-peak and slows the recession back to baseflow.

Physico-chemistry: water colour will generally be clear, although it may be discoloured due to resuspension of deposited material during periods of high flow. Alkalinity is medium to high, and, pH is typically 7 or higher.

River Type 15:

medium sized catchment area (100-1000km²), mean catchment altitude- medium (200-800m), with a predominantly organic surface geology.

Type overview: This is a rare river type occurring in the far NE of Scotland, and the Pennines in England covering <1% of the typed rivers in GB.

Macrophytes and phytobenthos: There are similarities with types 3, 6 and 9 but vegetation cover tends to be sparser and due to the increased relative importance of bryophytes species richness is somewhat higher (c. 35 species per reach). Both *Juncus bulbosus* and *Myriophyllum alterniflorum* are widespread (occurring at more than half of the sites) and often abundant but the other main aquatic vascular species (*Callitriche hamulata*, *Potamogeton polygonifolius*, *P. natans*, *Littorella uniflora*, *Sparganium angustifolium*) are more restricted in their occurrence. The most typical instream bryophytes are *Pellia epiphylla*, *Racomitrium aciculare*, *Brachythecium plumosum*, *Rhynchostegium riparioides*, *Scapania undulata* and *Hygrohypnum luridum* while mire forming species such as *Sphagnum* and *Calliergon cuspidatum* dominate marginal habitats. The commonest large emergent species are *Carex rostrata*, *Equisetum fluviatile* and *Phalaris arundinacea* which occur in association with various smaller marginal species such as *Galium palustre*, *Ranunculus flammula*, *Hydrocotyle vulgaris*, *Caltha palustris*, *Montia fontana*, *Mentha aquatica* and *Carex nigra*.

Epilithic diatom biofilms are dominated by *Achnantheidium* and *Eunotia* spp. The proportion of *Eunotia* will increase as acidity increases. Other taxa tolerant of acid conditions or occasional acidic episodes that might be found include *Peronia fibula*, *Tabellaria flocculosa*, *Brachysira vitrea*, *Frustulia* sp and *Psammothidium helveticum*.

Fish: In Scotland this type supports an impoverished fish fauna typically including Atlantic salmon, brown trout, eels and on occasions 3 spine sticklebacks. In England, fish populations are again impoverished including species such as brown trout, bullhead, minnow and possibly brook lamprey.

Macroinvertebrates: This type supports a diverse range of species that show a preference for base poor conditions. Mayfly species may include *Baetis rhodani* as well as *Ephemerella ignita*, *Rhithrogena semicolorata*, *Heptagenia lateralis*, *Ecdyonurus* spp and *Caenis rivulorum*. Stoneflies encountered may include *Leuctra* spp., *Chloroperla torrentium*, *Amphinemura sulcicollis*, *Isoperla grammatica*, *Protonemura meyeri* and members of the Perlidae and Perlodidae families. Caddis larvae are well represented by members of the families Hydropsychidae, Philopotamidae, Polycentropidae, Rhyacophilidae, Limnephilidae, Lepidostomatidae, Leptoceridae and Hydroptilidae

Morphology: medium size rivers flowing through peat dominated landscapes. The lower reaches may be subject to peat deposition washed down in high flows such that the deeper slow flowing areas may be covered in fine particulate peat, while faster flowing areas may have a sand, gravel or cobble substrate.

Hydrology: Organic catchments are generally saturated, with a low baseflow index. They therefore exhibit a rapid response to rainfall events. Greater rainfall is experienced at higher elevations so these rivers show increased discharges per unit catchment area. However, the larger upstream area of medium sized catchment subdues the speed of the hydrological response to rainfall. This extends the hydrograph time-to-peak and slows the recession back to baseflow.

Physico-chemistry: water colour may be stained brown, which limits light penetration. Alkalinity is very low, and pH values are typically < 6 although at times they may approach neutral.

River Type 16:

large catchment area (>1000km²), mean catchment altitude- medium (200-800m), with a predominantly siliceous geology.

Type overview:

Although this is an uncommon type across GB its location at the bottom end of the largest upland GB rivers, leads to it being one of the most commonly recognised types by the public. In Scotland they drain the east facing catchments of montane areas. Examples are also found in NW England and Wales.

Macrophytes and phytobenthos: Compared to Type 17 vegetation cover is relatively sparse due to the combination of bed movement, periodic high flows, deep water and a lack of fine substrate although species richness is often high due to physical heterogeneity (40-45 species). The most extensive development of vegetation occurs in secondary channels protected by lateral point bars and especially in palaeo-channels with a permanent down stream connection. The only truly widespread aquatic vascular species are *Myriophyllum alterniflorum* and *Callitriche hamulata* which occur in more than two thirds of sites but *Juncus bulbosus* and *Littorella uniflora* are frequent and locally abundant and in more sheltered situations often occur along side *Potamogeton polygonifolius*, and *P. natans*. The major tall emergent species *Phalaris arundinacea*, *Juncus acutiflorus*, *Carex rostrata*, *C. aquatilis*, *Sparganium erectum* and *Equisetum fluviatile* are similarly restricted outside such sites. Among lower plants only *Fontinalis* spp, and *Rhynchosygetium riparioides* are both widespread and abundant although a range of other species including *Pellia epiphylla*, *Schistidium* spp, *Scapania undulata*, *Brachythecium* spp, *Dichodontium pellucidum*, *Hygrohypnum ochraceum*, *Racomitrium aciculare*, *Dermatocarpon fluviatile* and *Lemanea* are commonly present in small quantity and may be locally abundant. On these rivers the smaller marginal flora is comparatively impoverished and is based mainly around *Ranunculus flammula*, *Myosotis scorpioides*, *Caltha palustris*, *Eleocharis palustris*, *Carex nigra*, *Glyceria fluitans* and *Mentha aquatica*. However, the terrestrial vegetation of gravel bars can be extremely diverse, combining elements of the flora of montane screes and coastal shingles, some of which are regionally or nationally rare.

Epilithic diatom biofilms are dominated by *Achnantheidium* and *Eunotia* spp. The proportion of *Eunotia* will increase as acidity increases. Other taxa tolerant of acid conditions or occasional acidic episodes that might be found include *Peronia fibula*, *Tabellaria flocculosa*, *Brachysira vitrea*, *Frustulia* sp and *Psammothidium helveticum*.

Fish: Northern examples in Scotland support Atlantic salmon, brown trout, eels and lampreys, while southern examples also include minnows, stone loach, and 3 spined sticklebacks. In England and Wales populations are likely to include brown trout, bullhead, minnow and/or brook lamprey. Where there are no natural barriers to migratory fish, salmon, sea trout and/or eel (typically at sites not too far from the sea) are to be expected together with river and/or sea lamprey.

Macro-invertebrates: This type supports a diverse range of species due to the range of habitats created by the inter-play of current and substrate conditions. However, some species associated with smaller rivers may also be absent. The gastropod fauna may be more diverse than that encountered in small rivers and the pearl mussel *Margaritifera margaritifera* is characteristic. Mayfly species may include *Baetis rhodani* as well as, *Rhithrogena semicolorata*, *Heptagenia lateralis*, *Ecdyonurus* spp and *Caenis rivulorum*. *Ephemerella ignita*, *Centroptilum luteolum* and *Leptophlebia marginata* may occur in increasing numbers relative to similar smaller rivers. Stoneflies encountered may include *Nemurella picteti*, *Chloroperla torrentium*, *Amphinemura sulcicollis*, *Isoperla grammatica*, *Protonemura meyeri* and members of the Perlidae and Perlodidae families. However, *Nemoura* spp. are uncommon and *Leuctra nigra*, *L. hippopus* and *Capnia* spp are likely to be absent. Caddis

larvae are well represented by members of the families Hydropsychidae, Philopotamidae, Polycentropidae, Rhyacophilidae, Limnephilidae and Hydroptilidae with additions when compared to smaller rivers of *Brachycentrus subnubilis*, *Lepidostoma hirtum*, *Sericostoma personatum* and *Odontocerum albicorne*.

Morphology: this type covers the middle and lower sections some of the larger Scottish rivers. These meandering rivers may be depositional in nature with a tendency to form bars and are characterised by runs, glides, riffles and pools. Substrate may vary from sand, silt, gravel cobbles and occasionally boulders.

Hydrology: Siliceous catchments are likely to have a low baseflow index. The hydrological regime will have a lesser degree of connectivity with groundwater and exhibit a relatively rapid hydrological response to rainfall events. However, large catchments show an extended hydrological response to rainfall, resulting in longer time-to-peak and a slow recession back to baseflow conditions compared with smaller catchments of similar geological type. Increased rainfall at medium elevations means these rivers show increased discharges per unit catchment area.

Physico-chemistry: These generally unproductive rivers usually run clear, although they can be coloured by humic substances or the resuspension of deposited material during spates. Alkalinity is typically low, and pH commonly ranges between 6 and 7.

River Type 17:

large catchment area (>1000 km²), mean catchment altitude- medium (200-800m), with a predominantly calcareous geology.

Type overview: in England and Wales, this type of river is scattered but mainly occurs in northern areas and Wales. It covers less than 1% of river length across GB. In Scotland it is extremely uncommon, occurring only at the lower 10km of the River Clyde which is heavily urbanised and not at reference conditions.

Macrophytes and phytobenthos: Outside the deeper central channel of these rivers coverage by aquatic plants is often extensive. The vegetation is species rich (40-50 species per reach) and is typically based around a combination of *Ranunculus fluitans* (or various sterile hybrids), and/or *Ranunculus penicillatus pseudofluitans*, *Myriophyllum spicatum*, *Potamogeton crispus* and *P. perfoliatus* growing on sands and finer gravels with *Persicaria amphibia* along more sheltered margins. *Potamogeton pectinatus* (and occasionally its hybrids), *Zannichellia palustris*, *Sparganium emersum* and *Callitriche* spp are often present within this matrix and large and highly persistent populations of several of the larger hybrid pondweeds (*P. x salicifolius*, *P. x olivaceus*) may also occur. This vegetation is interspersed with coarser substrates on which lower plants such as *Rhynchosstegium riparioides*, *Fontinalis antipyretica*, *Cinclidotus fontinaloides*, *Pellia endiviifolia*, *Hildenbrandia*, *Lemanea*, *Amblystegium riparium*, *Heribaudiella fluviatilis* commonly occur in addition to extensive growths of filamentous algae. In terms of larger emergent species *Phalaris arundinacea*, *Epilobium hirsutum* and *Sparganium erectum* are virtually ubiquitous as are smaller herbs such as *Myosotis scorpioides*, *Mentha aquatica* and *Veronica beccabunga*. Widespread associates include *Eleocharis palustris*, *Rorippa sylvestris*, *Glyceria fluitans*, *Alisma plantago-aquatica*, *Stachys palustris* and *Lycopus europaeus*. Some sites also support large, seemingly naturalised populations of *Butomus umbellatus* growing outside its native range.

Epilithic diatom biofilms are dominated by *Achnantheidium* spp, along with other pollution-sensitive taxa such as *Meridion circualre*, *Hannaea arcus*, *Fragilaria capucina (sensu stricto)*, several *Cymbella* spp and some *Gomphonema* spp. *Didymosphenia geminata*, *Achnanthes oblongella* and *Psammothidium* spp are sometimes abundant. *Cladophora glomerata* will either be absent or form only a small part of the total photosynthetic biomass.

Fish: This type commonly supports a mixture of coarse and resident salmonid species and is commonly used as a migratory corridor by salmonids, eel and lampreys. Typical species include brown trout, grayling, bullhead, chub and dace. Where proximate to transitional

waters, some fish species associated with that habitat e.g. flounder, may occasionally be found.

Macroinvertebrates: the fauna will be diverse with a good complement of rithral mayflies and caddis. Significant regional variations in composition and diversity are likely to occur across Great Britain, however Oligochaeta, Gammaridae, Baetidae, Heptageniidae, Elmidae, Hydropsychidae, Chironomidae and Simuliidae are almost always present. Planariidae, Ancyliidae, Sphaeriidae, Caenidae, Leuctridae and Leptoceridae are frequent. Although infrequent, Potamanthidae may occur.

Morphology: These rivers are geographically widespread, they generally on shallow slopes, and exhibit wide variation in channel width and depth. In the lower reaches extensive meanders and connectivity with the floodplain wetlands will occur. A wide range of substrates are found, with increasing tendency towards deposition of silt in the downstream reaches, both in-channel and in the floodplain.

Hydrology: Calcareous catchments are likely to have a high baseflow index. The hydrological regime will therefore exhibit a greater degree of connectivity with groundwater and a delayed and subdued hydrological response to rainfall events. Increased rainfall is experienced at medium elevations, so these rivers can therefore be expected to show increased discharges per unit catchment area. The large upstream area of the catchment further reduces the speed of the hydrological response to rainfall, giving an extended time-to-peak and slowing the recession back to baseflow.

Physico-chemistry: water colour will generally be clear, although it may be discoloured due to resuspension of deposited material during periods of high flow. pH is typically 7 or higher, and alkalinity is medium to high.

River Type 18:

medium sized catchment area (100-1000km²), mean catchment altitude- high (>800m), with a predominantly siliceous geology.

Type Overview: An uncommon exclusively Scottish high altitude type located in the Cairngorm and Grampian massifs, covering <1% of the typed river length across GB.

Macrophytes and phytobenthos: Vegetation is heavily dominated by bryophytes. The commonest instream species occurring in more than half the sites are *Pellia epiphylla*, *Racomitrium aciculare* and *Scapania undulata*. The larger patch forming mosses such as *Fontinalis* spp, *Brachythecium* spp, *Hygrohypnum ochraceum* and *Rhynchostegium riparioides*, and classic upland leafy liverworts such as *Jungermannia atrovirens*, *Marsupella emarginata* and *Nardia compressa* are all well represented. Due to the hydrological responsiveness of these streams the emergent rock and gravel habitat is often extensive and favours species such as *Schistidium alpicola* and *Dichodontium pellucidum*, while incoming flushes and waterfalls create additional areas of wet rock occupied by species such as *Hyocomium armoricum*, *Dicranella palustris* and *Philonotis fontana*. With the exception of *Juncus bulbosus* rooted aquatic vascular species are scarce although some lower gradient sections with patches of finer sediment may support *Myriophyllum alterniflorum*, *Potamogeton polygonifolius*, *Callitriche hamulata* or *Littorella uniflora*. Emergent vegetation is restricted to smaller species associated with periodically inundated blanket peat (e.g. *Juncus acutiflorus*, *Carex nigra*, *C. rostrata*, *Hydrocotyle vulgaris*, *Galium palustre*, *Caltha palustris*, *Ranunculus flammula*), flush zones (e.g. *Montia fontana*) or stabilised gravel bars (e.g. *Juncus articulatus*, *Equisetum arvense*). Cover and species richness of such sites is highly variable depending on slope and bed stability. Some high altitude, mobile gravel bed streams are almost unvegetated, while larger streams with extensive bedrock or boulders may support a comparatively diverse and extensive flora.

Epilithic diatom biofilms are dominated by *Achnanthyidium* and *Eunotia* spp. The proportion of *Eunotia* will increase as acidity increases. Other taxa tolerant of acid conditions or occasional acidic episodes that might be found include *Peronia fibula*, *Tabellaria flocculosa*, *Brachysira vitrea*, *Frustulia* sp and *Psammothidium helveticum*.

Fish: in the source waters no fish are present, although brown trout can occur in rivers at the lower end of the altitude range.

Macroinvertebrates: The fauna is restricted by harsh climatic conditions to species that are confined to or can tolerate higher altitudes. Species of Naidid and enchytraeid worms, nematodes, chironomids, simuliids may be present. Some mayfly species namely *Ameletus inopinatis*, *Baetis rhodani* & *Rhithrogena semicolorata*; stoneflies such as *Protonemura montana*, *Diura bicaudata*, *Leuctra* species, *Capnia bifrons* & *Chloroperla torrentium* as well as various caddis larvae e.g. *Allogamus auricollis*, *Philopotamus montanus*, *Plectrocnemia conspersa* and *P. geniculata* can be found in these extreme conditions.

Morphology: upper reaches drain eastwards into two significant catchments, namely the Spey and the Dee. Flow is likely to be fast and turbulent and subject to spates leading to a preponderance of eroding habitats. Substrates range from bedrock and boulders in the steeper more turbulent areas to cobbles and gravel below the areas of extreme erosion.

Hydrology: Siliceous catchments are likely to have a low baseflow index. The hydrological regime will have a lesser degree of connectivity with groundwater and exhibit a rapid response to rainfall events. Greater rainfall is experienced at higher elevations so these rivers can be expected to show increased discharges per unit catchment area. The greater upstream area of medium sized catchments will moderate the speed of hydrological response to rainfall, compared to small catchments of the same geological type, but the hydrograph time-to-peak and recession to baseflow will still be relatively speedy.

Physico-chemistry: water colour will generally be clear, with pH values typically of 6 or lower.