Natural England Commissioned Report NECR140

New Forest SSSI Geomorphological Survey Overview

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Foreword

Natural England commission a range of reports from external contractors to provide evidence and advice to assist us in delivering our duties. The views in this report are those of the authors and do not necessarily represent those of Natural England.

Background

The New Forest contains significant areas of habitats that are now rare and fragmented across lowland Western Europe, including lowland heath, valley and seepage step mire or fen, and ancient pasture woodland, including riparian and bog woodland. It is also important for its stream network, that drains the mire habitats, which form an unusual community due to the combination of nutrient-poor, acid waters and outcrops of neutral, enriched soils.

The damage caused by historical drainage activities and contemporary engineering/ management of the mire systems and modification of rivers and streams is frequently cited as a reason for unfavourable condition of the New Forest SSSI units. Natural England aims to restore these to favourable condition and to do this needs to understand the physical habitat and ecohydrogical processes and forms of the mire/wetland floodplain habitats. This includes:

1) Undertaking a geomorphological analysis and ecological interpretation of physical impacts on the river and floodplain.
2) Identifying the floodplain features and SAC habitats associated with the abandoned and active floodplains and describing the impact of watercourse modification and other drainage activities.
3) Preparing ecohydrogical/hydrogeological characterisation of the mires following a full analysis of data already available supplemented by field data.
4) Providing brief details of the physical restoration opportunities for each mire and their logical sequencing at hydrological catchment and New Forest scales.
5) Reviewing the current body of evidence and suggest what longer term monitoring could be put in place to provide a national set of scientific evidence to support wetland restoration.

This report provides an overview of the geomorphological survey conducted in the New Forest. Annexes A to R contain the individual reports for each survey area. It supports the annexes and includes the background information used to help populate the individual annexes. Other reports that contribute to the project are:

- New Forest SSSI Ecohydrological Survey Overview (NECR141);
- Geomorphic and Ecohydrological Monitoring and Prioritisation Report (NECR142); and
- Latchmore Brook Restoration Options Appraisal (NECR143).

Natural England Project Officer - Jinti Gifford, Natural England, Cromwell House - 2nd Floor, 15 Andover Road, Winchester, Hampshire, SO23 7BT **jinti.gifford@naturalengland.org.uk**

Contractor - George Heritage, JBA Consulting, Bank Quay House, Sankey Street, Warrington, Cheshire, WA1 1NN

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Further information
This report can be downloaded from the Natural England website: **www.naturalengland.org.uk**. For information on Natural England publications contact the Natural England Enquiry Service on 0845 600 3078 or e-mail **enquiries@naturalengland.org.uk**.

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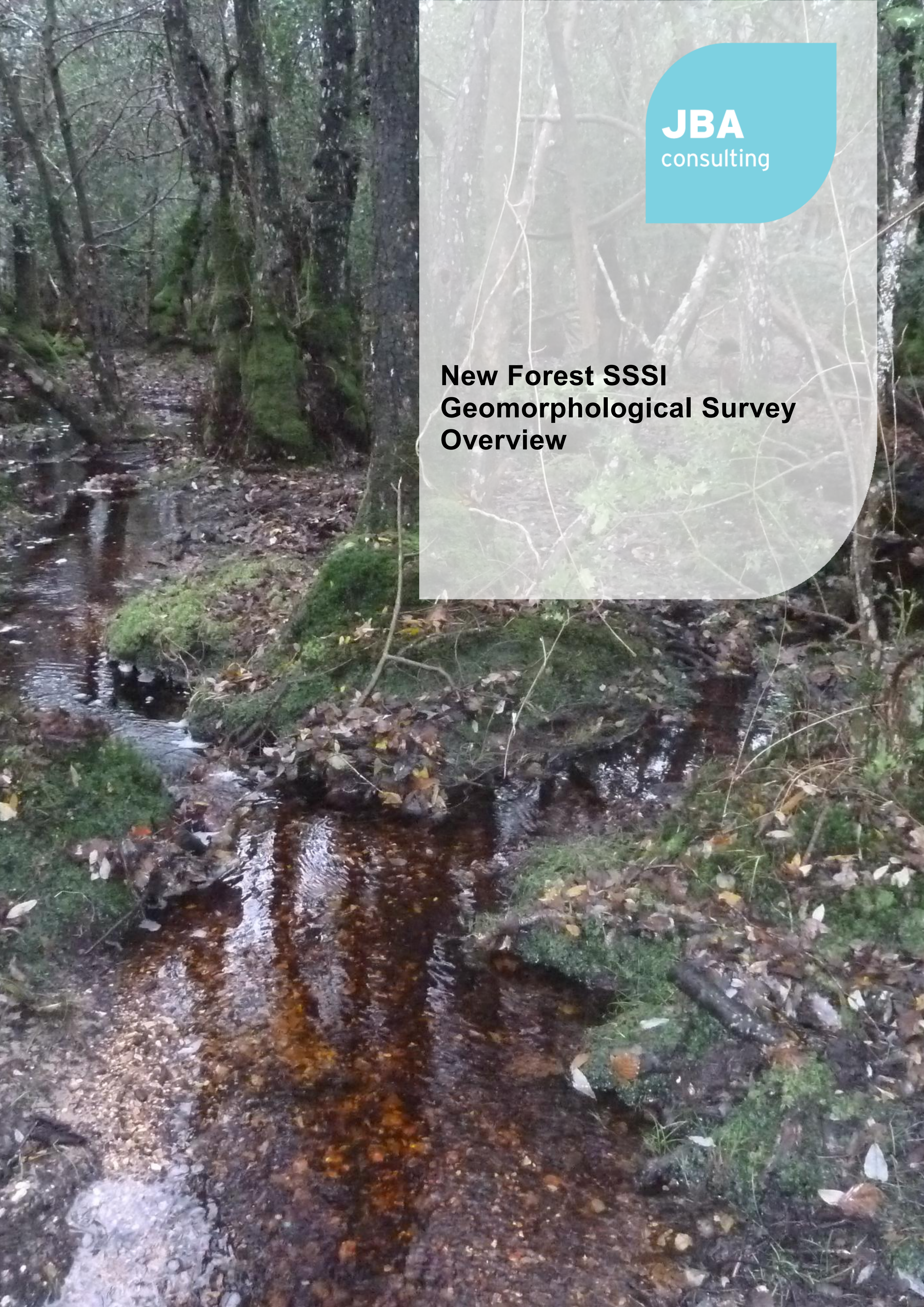


JBA consulting

New Forest SSSI Geomorphological Survey Overview

Executive Summary

This report gives an overview of the geomorphological and ecological survey of several New Forest SSSI units conducted by JBA on behalf of Natural England in the autumn/winter of 2012.

Unit specific restoration plans for the geomorphological assessment areas have been produced and are presented in the Annexes to this report. Restoration plans have been defined using form and process information gathered during the audit work, past restoration techniques adopted in the New Forest, scientific literature and other desk based material including aerial photography and LIDAR.

Restoration measures are designed to work with existing processes and to encourage naturalisation of the SSSI units so that they can achieve favourable condition.

A monitoring strategy has been constructed to allow pre and post geomorphological and ecological monitoring to be undertaken to determine system response to restoration.

Where applicable, further assessments have been highlighted that are likely to be required as restoration plans are taken forward, refined and submitted for planning. This includes recommendations for Flood Risk Assessments and engineering assessments where structures are proposed for modification.

As restoration plans are developed through consultation and the planning process, changes and further detail are likely to be included before a final restoration design has been agreed.

Contents

List of Figures

List of Tables

Abbreviations

BGS .... British Geological Survey

CEH .... Centre for Ecology and Hydrology

FEH................................ Flood Estimation Handbook

GIS................................. Geographic Information System

JNCC .... Joint Nature Conservation Committee

LIDAR .... Light Detection And Ranging

OS.................................. Ordnance Survey

SAC................................ Special Area of Conservation

SPA................................ Special Protection Area

SSSI............................... Site of Special Scientific Interest

WETMECS...................... WETland water supply MEChanismS

1 Introduction

1.1 Overview

This report gives an overview of the geomorphological and ecological survey of several New Forest SSSI units conducted by JBA on behalf of Natural England in the autumn/winter of 2012. The results of the geomorphological and ecological survey for each site is presented in the Annexes which supplement the report, however they are dependent upon background information presented in this overview report.

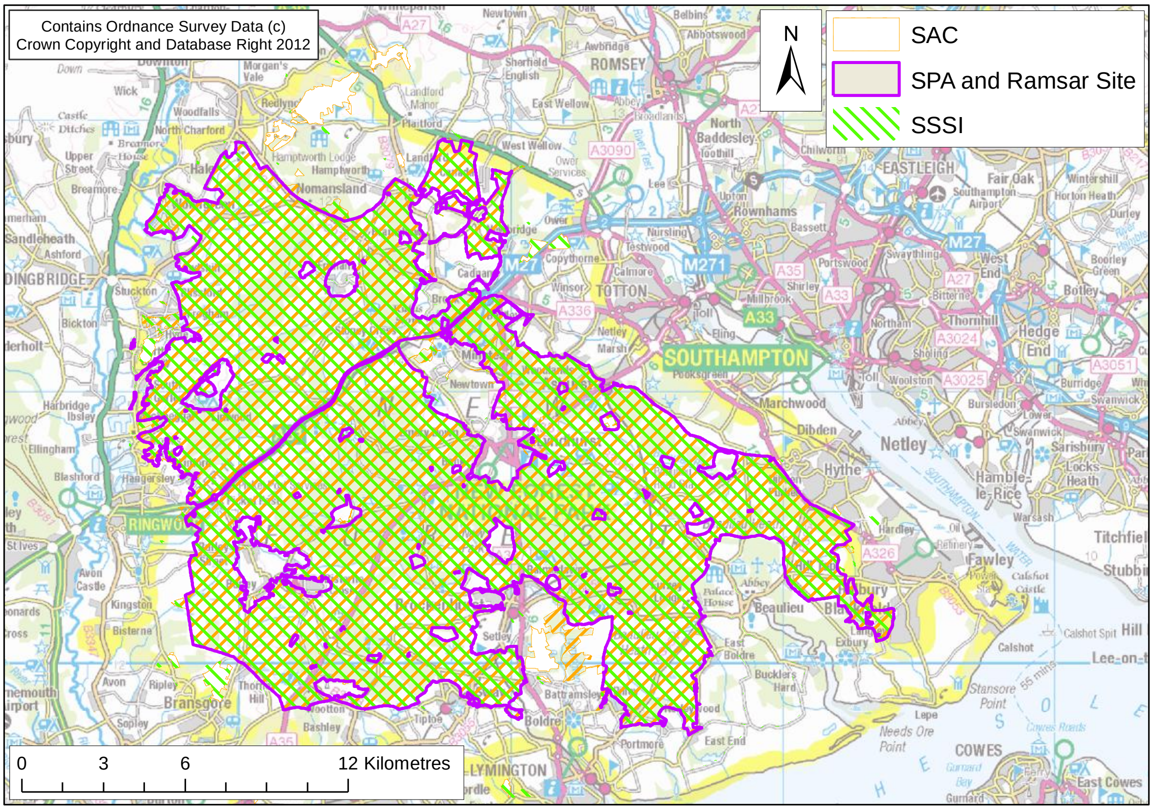
The results of the eco-hydrological surveys within the mire dominated units are provided within a separate report. Transition sites (i.e. mire to stream) have been covered, where appropriate, within both reports.

1.2 The New Forest

The New Forest is of exceptional importance, containing significant areas of habitats that are now rare and fragmented across lowland Western Europe, including lowland heath, valley and seepage step mire, or fen, and ancient pasture woodland, including riparian and bog woodland (Natural England, 1987). The New Forest is also important for its stream network, often draining the mire habitats, which form an unusual community due to the combination of nutrient-poor, acid waters and outcrops of neutral enriched soils.

The forest is also internationally important for breeding bird populations and over-wintering bird populations (e.g. Hen Harrier *Circus cyaneus*, Dartford Warbler *Sylvia undata*); for its rich invertebrate fauna, including Stag Beetle *Lucanus cervus* and Southern Damselfly *Coenagrion mercuriale*; number of scarce plants and fungi (e.g. Hampshire Purslane *Ludwigia palustris*, Wild Gladiolus *Gladiolus illyricus*, Pennyroyal *Mentha pulegium* and Slender Marsh Bedstraw *Galium constrictum*, Dorset Heath *Erica ciliaris*) and rare fauna including Bechstein's Bat *Myotis bechsteinii*, Sand Lizard *Lacerta agilis*, Smooth Snake *Coronella austriaca* and Great Crested Newt *Triturus cristatus*. Consequently, the area has been designated as a Special Area of Conservation (SAC), Special Protection Area (SPA), a Ramsar wetland and a Site of Special Scientific Interest (SSSI) and the UK government has a responsibility to ensure that the site is in good condition. The location of the designated areas is shown in Figure 1-1 below.

Figure 1-1: The New Forest Designated Site Boundaries



1.3 Project Background

The project focuses specifically on the stream network and modified mire systems of the New Forest SSSI.

One of the key factors causing concern in the New Forest is the damage caused by historical drainage activities and contemporary engineering/management of the mire systems and modification of rivers and streams which impacts on the eco-hydrological functioning of these interlinked systems. This is frequently cited as a reason for 'unfavourable condition' of the SSSI. Natural England's objective in the New Forest is to restore favourable condition to habitats that have been impacted by direct modification. Natural England is therefore looking to develop a restoration plan to bring the New Forest SSSI into favourable condition through a programme of geomorphological assessments of the channels and floodplains, and eco-hydrological characterisation of the mires, which will result in the generation of recommendations for functional restoration of the New Forest SSSI.

1.3.1 Project Aims and Objectives

The aim of the project is to establish the physical habitat, eco-hydrological and geomorphological processes and forms typical of the headwater mire/stream channel/wetland floodplain habitats within a number of units of the New Forest SSSI to provide clear baseline data and recommendations on which a strategic operational restoration programme can be designed.

The specific objectives are:

1. To undertake a geomorphological analysis and ecological interpretation of physical impacts on the river and floodplain;
2. To identify the floodplain features and SAC habitats associated with the abandoned and active floodplains and describe the impact of watercourse modification and other drainage activities;
3. To prepare eco-hydrological/hydrogeological characterisation of the mires following a full analysis of data already available supplemented by field data;
4. To provide brief details of the physical restoration opportunities for each reach/mire and their logical sequencing at hydrological catchment and New Forest scales;

5. To review the current body of evidence and suggest what longer term monitoring could be put in place to provide a national set of scientific evidence to support wetland restoration.

1.3.2 Purpose of Report

This report provides an overview of the geomorphological and ecological survey conducted in the New Forest. Individual reports have been written for each survey area (see Annexes) however this report provides background information and discussions which support the information contained within the individual reports. The reports should therefore be read in conjunction with each other.

A separate report and a restoration plans have been produced for the eco-hydrological sites.

2 Methodology

2.1 Introduction

The following chapter summarises the methodology followed for the geomorphological and ecological investigation into the modified streams and wetlands of the New Forest SSSI.

2.1.1 Holistic Approach

National guidelines for the physical and geomorphological restoration of SSSI rivers (Mainstone, 2007) aim ‘to direct physical restoration efforts away from ad hoc, opportunistic, reach based activities to whole-river, strategic plans based around the concept of assisted natural recovery, with sequenced practical measures, clear roles for all interested parties, and identified resourcing mechanisms’. It is this holistic approach that is applied throughout this study.

Fundamental to developing a sustainable holistic restoration plan is the recognition of the river and floodplain environment as a functional unit where connectivity has been broken due to historic activities. To ensure a holistic approach is applied in this study, and that all aspects (i.e. ecology, hydrogeology and geomorphology) are integrated, the field work was undertaken by teams consisting of one ecologist and one geomorphologist and/or hydrogeologist, depending on the type of site (i.e. mire, stream or transition site). Completion of the fieldwork as an integrated team during a single survey period facilitated the sharing on the ground of findings during the survey, allowing for a rapid exchange of ideas and generating improved understanding over isolated survey approaches. This integrated hydromorphological and eco-hydrological assessment approach was strongly linked to protocols developed by Mainstone (2007) and Wheeldon *et al*. (2010).

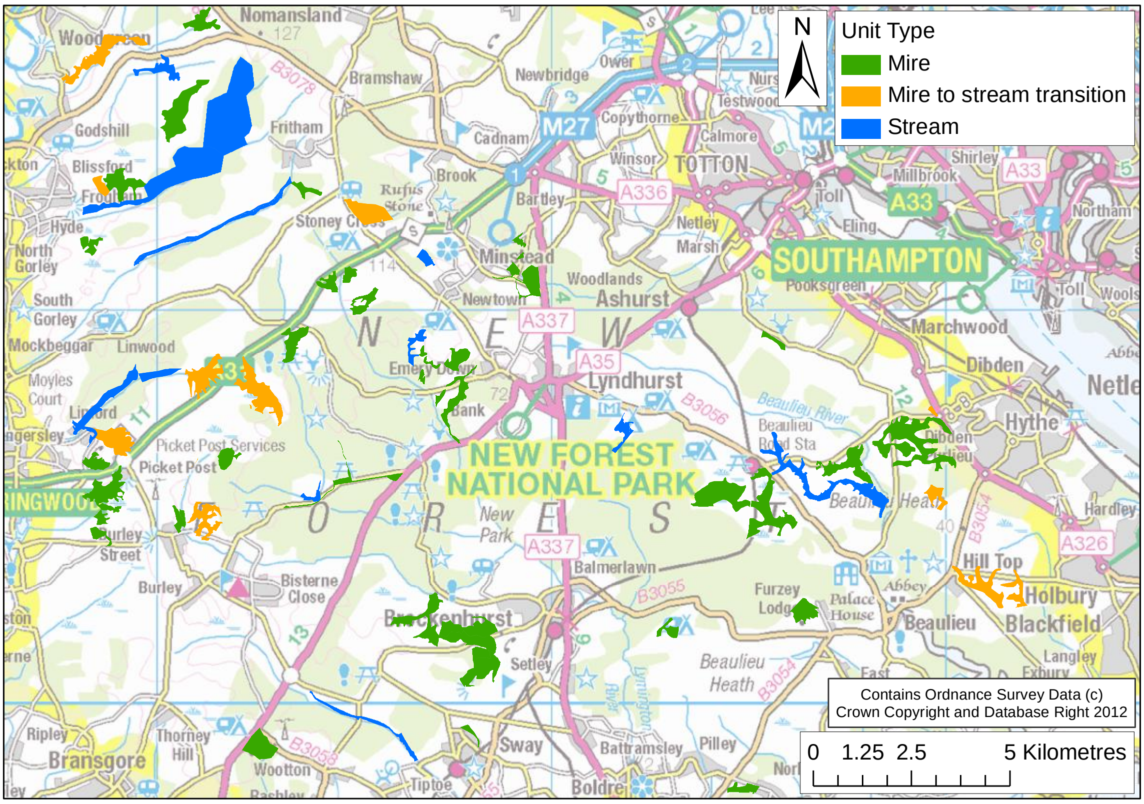
2.1.2 Sites for Investigation

This project focuses on 52 units of the New Forest SSSI, some of which are composed of a number of discrete sites. These units have been categorised as mires, streams or mire to stream transition sites. The location and type of each site is shown in Figure 2-1 below.

The methodology of assessment for the geomorphological and eco-hydrological investigations undertaken in this study differed depending on the type of unit. The stream units were subject primarily to a geomorphological assessment, whereas on the mire units the key method of assessment was an eco-hydrological investigation. The mire to stream transition units were subject to both methods of assessment.

The methodology for each unit type is described below and each is discussed in separate chapters of this report.

Figure 2-1: SSSI Units for Assessment

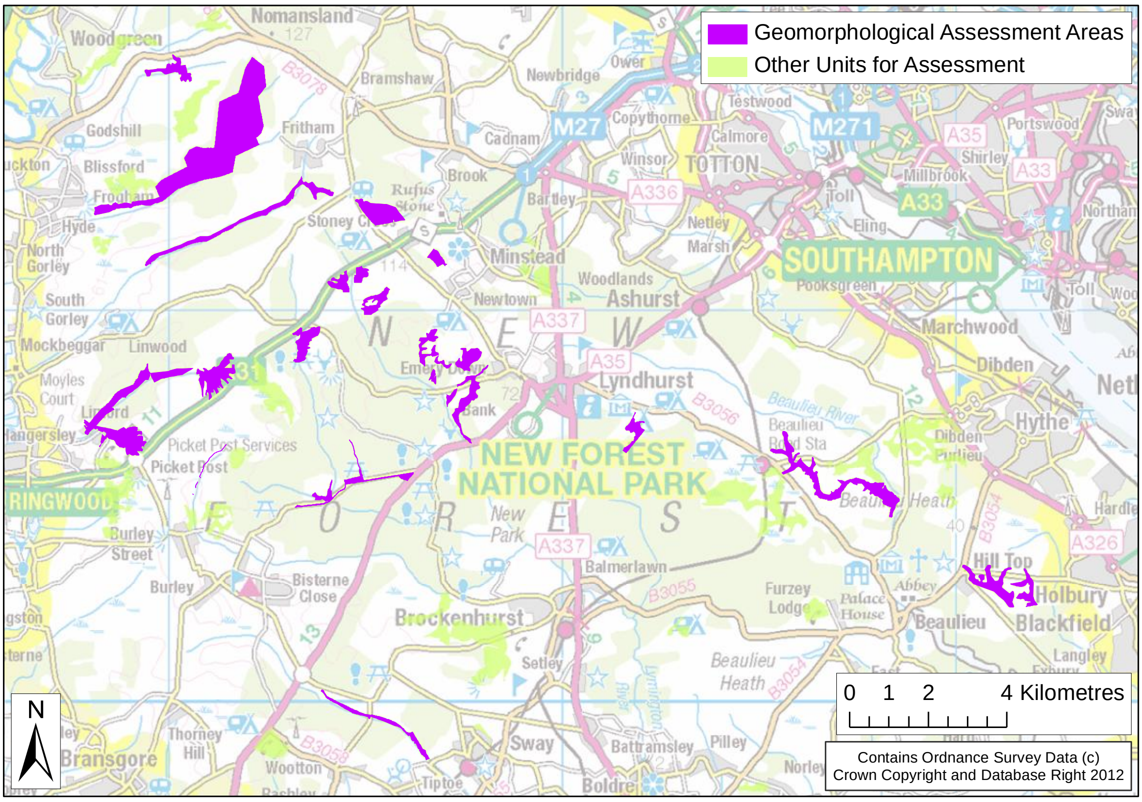


2.2 Geomorphological Assessment Methodology

2.2.1 Desk study

The first stage of the geomorphological and ecological assessment, which was principally undertaken on the stream units termed 'Geomorphological Assessment Areas' (see Figure 2-2), was a desk study to identify baseline data and historic changes to the New Forest SSSI and understand previous research into the system, discussed further in section 3.3. Aerial photograph analysis was conducted to allow a targeted field campaign of hydromorphological and ecological data collection. Information from these studies was then assimilated into a conceptual holistic model of system form and function, paying particular attention to process based functional linkages between the mosaic of river, floodplain and wetland habitats seen across the New Forest SSSI.

Figure 2-2: Geomorphological Assessment Areas



This desk-based assessment provided a spatial and chronological account of the modifications that have occurred on the river, floodplain and wetland habitats, highlighting key geomorphological features and function, linking alterations to the functional system to ecological response. It utilised all relevant archive sources including ENSIS data, JNCC river type information for the SSSI and reports linked to wider research on hydrological, ecological and geomorphological damage to the New Forest. An additional search of web-based imagery and aerial photography was made to supplement data already held. These data and information helped to identify the key issues of concern.

2.2.2 Fluvial Audit and modelling

Following the desk-based assessment a field survey was undertaken to evaluate the geomorphological nature and dynamics of the habitats of the New Forest SSSI, taking into account historic system functioning, legacy issues, wider catchment factors and local influences on river, floodplain and wetland system structure and behaviour. Contemporary morphology and processes were audited and mapped and compared with historic records and sedimentological inferences of past channel behaviour. Examples of near pristine natural sites were identified (e.g. lowland anastomosed within unit 368) and used to determine the optimum geomorphological conditions for the SSSI. Qualitative models of linked channel, floodplain and wetland behaviour at the morphologic unit scale have also been developed to predict reaction to natural and imposed change factors and these have been linked to the ecological response.

System morphology and process has been mapped in a GIS geodatabase, alongside reaches categorised according to 'naturalness' and the type of modification. Catchment scale, potentially destabilising phenomena, have also been identified and more local system modifications and structures recorded. Areas exhibiting a desirable geomorphological state have been highlighted and other habitats categorised using a quality/modification matrix to assist with targeting restoration activities.

2.2.3 Ecological Survey

The ecological aspect of the field work involved the undertaking of a detailed Extended Phase 1 Habitat Survey of the streams and associated floodplains in accordance with the Handbook for Phase 1 Habitat Survey (JNCC, 1990). This recorded the key habitats present within each unit and the key botanical components of each. However, it should be noted that the timing of the survey work for this project (being November 2012) is a sub-optimal period for recording plant species; the species lists compiled are therefore limited.

Notable features and areas too small to map were target noted and fully surveyed. In particular, the survey focussed on the bed, banks, bar features and associated floodplains of the streams. Functional relationships between the biota and the morphology were also noted.

Within the stream units, in-channel vegetation was surveyed at approximately 500m intervals over the entire reach, although in some places access restricted the number of survey points that could be sampled. All sample points were geo-located and photographs taken upstream, downstream and of the channel itself (where possible) at each sample location. This survey was based on the methodology in the Common Standards Monitoring Guidance for Rivers (JNCC, 2005) and will allow the compilation of a preliminary baseline of the river flora to give a reference against which future monitoring can be conducted. It also helped in describing the current channel and floodplain ecology, against which impacts of modification have been assessed.

In addition, all incidental observations of notable flora and fauna and their field signs were noted.

2.3 Mire to Stream Transition Sites

The mire to stream transition sites were subject to both a geomorphological assessment and an eco-hydrological investigation and therefore the methodologies described in both this report and the eco-hydrological report have been followed.

There are 11 mire to stream transition SSSI Units within the study. They were subject to a geomorphological assessment, or an eco-hydrological investigation, or both, as required (see Table 2-1). In general the transition sites fell into two categories:

- Sites with mires and streams (or rivers) but the two were separate with little transition.
- Sites with mires transitioning into small streams from collects.

Only Unit 33 fell into the first category. It was important that this site was surveyed by using both the Geomorphological (see geomorphological overview report) and ecohydrology methodologies. For the latter and larger group, both survey methodologies were likely to identify areas of damage and suitable restoration measures. This is because both surveys focused on small streams within and discharging from the mires, and the potential damage both within and surrounding those features.

Table 2-1: Survey types completed on Transitions SSSI Units

Unit Number	Geomorphological Survey	Ecohydrology Survey
43	Yes	Yes
422	Yes	No
129	No	Yes
123	Yes	Yes
419	No	Yes
33	Yes	Yes
423	Yes	No
91	Yes	No
112	Yes	Yes
95	Yes	Yes
126	Yes	No

For the six SSSI unit which were only surveyed by one survey group (either geomorphological or ecohydrological), the unit or Ecohydrological Assessment Area reports will cover both aspects required. The ecohydological and geomorphological reports for the remaining sites will cross reference their findings.

2.4 SAC Habitat Mapping

An additional aspect of this project, using the findings of the Extended Phase 1 Habitat survey, will be the identification of floodplain features and the presence, location and extent of SAC habitats associated with abandoned or active floodplains. The New Forest SSSI is designated for a number of Annex I habitats, which are:

- Oligotrophic waters containing very few minerals of sandy plains (*Littorelletalia uniflorae*)
- Oligotrophic to mesotrophic standing waters with vegetation of the *Littorelletea uniflorae* and/or of the *Isoëto-Nanojuncetea*
- Northern Atlantic wet heaths with *Erica tetralix*
- European dry heaths
- *Molinia* meadows on calcareous, peaty or clayey-silt-laden soils (*Molinion caeruleae*)
- Depressions on peat substrates of the *Rhynchosporion*
- Atlantic acidophilous beech forests with *Ilex* and sometimes also *Taxus* in the shrub layer (*Quercion robori-petraeae or Ilici-Fagenion*)
- *Asperulo-Fagetum* Beech forests
- Old acidophilous oak woods with *Quercus robur* on sandy plains
- Bog woodland
- Alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior (Alno-Padion, Alnion incanae, Salicion albae*)

Additionally, a further two Annex I habitats are present as a qualifying feature within the site, but are not a primary reason for selection of the site as a SAC. These are:

- Alkaline fens
- Transition mires and quaking bogs

However, not all of the above habitats are likely to be found within the units sampled, for example the drier woodland communities are unlikely to be encountered within mire and stream units. The SAC Annex I habitats likely to be found within the New Forest SSSI, typically the wetter communities, are detailed in Table 2-2 below, with a short description of each habitat type also provided.

Table 2-2: SAC Annex I Habitats likely to be recorded within the units surveyed (Source: JNCC Website, 2012)

SAC Annex I Habitat		Description	New Forest Context
4010	**Northern Atlantic wet heaths with *Erica tetralix***	Wet heath usually occurs on acidic, nutrient-poor substrates, such as shallow peats or sandy soils with impeded drainage. The vegetation is typically dominated by mixtures of Cross-leaved Heath *Erica tetralix*, Heather *Calluna vulgaris*, grasses, sedges and *Sphagnum* bog-mosses. In the UK this vegetation corresponds to the following NVC types: - H5 *Erica vagans – Schoenus nigricans* heath (A distinctive and unique wet heath form found on the Lizard in Cornwall) - M14 *Schoenus nigricans – Narthecium ossifragum* mire (A very local wet heath type mainly associated with transitions from heath to valley bog at a small number of lowland sites in southern Britain) - M15 *Scirpus cespitosus – Erica tetralix* wet heath (Found in areas with moderate to high rainfall. The typical wet heath form in the west of the UK) - M16 *Erica tetralix – Sphagnum compactum* wet heath (Characteristic of	The New Forest contains the most extensive stands of lowland northern Atlantic wet heaths in southern England, mainly of the M16 *Erica tetralix – Sphagnum compactum* type. M14 *Schoenus nigricans – Narthecium ossifragum* mire can also be found. The wet heaths are important for rare plants, such as Marsh Gentian *Gentiana pneumonanthe* and Marsh Clubmoss *Lycopodiella inundata*, and a number of dragonfly species, including the scarce Blue-tailed Damselfly *Ischnura pumilio* and Small Red Damselfly *Ceriagrion tenellum*. There is a wide range of transitions between wet heath and other habitats, including dry heath, various woodland types, *Molinia* grasslands, fen, and acid

SAC Annex I Habitat		Description	New Forest Context
		drier climates in the south and east, and is usually dominated by mixtures of *E. tetralix, Calluna* and *Molinia* and abundant *Sphagnum compactum*) Wet heath is an important habitat for a range of vascular plant and bryophyte species of an oceanic or Atlantic distribution in Europe. Northern Atlantic wet heaths with *Erica tetralix* are restricted to the Atlantic fringe of Europe between Norway and Normandy. A high proportion of the EU resource occurs in the UK, where it is highly localised in parts of southern and central England, but increasingly extensive in the cool and wet north and west.	grassland. Wet heaths enriched by Bog Myrtle *Myrica gale* are a prominent feature of many areas of the Forest. Unlike much lowland heath, the New Forest heaths continue to be grazed extensively by cattle and horses, favouring species with low competitive ability.
4030	**European dry heaths**	European dry heaths typically occur on freely-draining, acidic to circumneutral soils with generally low nutrient content. Ericaceous dwarf-shrubs dominate the vegetation, with Heather the most dominant, with Gorse *Ulex spp.*, Bilberry *Vaccinium spp*. or Bell Heather *Erica cinerea* important locally. Nearly all dry heath is semi-natural, being derived from woodland through a long history of grazing and burning. Most dry heaths are managed as extensive grazing for livestock or, in upland areas, as grouse moors. Twelve NVC types in Britain meet the definition of this habitat type, although not all forms of these communities equate to European dry heaths: - H1 *Calluna vulgaris – Festuca ovina* heath (Semi-continental heaths on the western Norfolk-Suffolk border, which are overwhelmingly dominated by Heather, sometimes with abundant lichens) - H2 *Calluna vulgaris – Ulex minor* heath (Occurs on dry acid soils in the lowlands of south-east and central southern England, and is typically dominated by mixtures of *Calluna, U. minor* and *E. cinerea*) - H3 *Ulex minor – Agrostis curtis*ii heath (Found on slightly damp soils in Dorset and the New Forest where Dwarf Gorse is frequent) - H4 *Ulex gallii – Agrostis curtisii* heath (An uncommon community on slightly damp soils in the mild, oceanic climate of south-west England and south Wales) - H7 *Calluna vulgaris – Scilla verna* heath - H8 *Calluna vulgaris – Ulex gallii* heath (Found at low to moderate altitudes in warm oceanic parts of southern Britain characterised by abundant *Calluna, U. gallii* and *E. cinerea*.) - H9 *Calluna vulgaris – Deschampsia flexuosa* heath (Found at low to moderate elevations in the less oceanic areas of north-east England and the Midlands. Often extensive species-poor heaths) - H10 *Calluna vulgaris – Erica cinerea*	The New Forest contains the largest area of lowland European dry heathland in the UK. It is particularly important for the diversity of its habitats and the range of rare and scarce species which it supports. The New Forest is unusual because of its long history of grazing in a traditional fashion by ponies and cattle. The dry heaths of the New Forest are of the H2 *Calluna vulgaris – Ulex minor* heath type, and H3 *Ulex minor – Agrostis curtisii* heath is found on damper areas. There are a wide range of transitions between dry heath and wet heath, *Molinia* grassland, fen, acid grassland and various types of scrub and woodland. New Forest also has an unusual community termed Humid Heath, this contains neither *Erica cinerea* nor *Sphagna* as it is both too wet and too dry for these species respectively. This zone is widespread across the New Forest.

SAC Annex I Habitat		Description	New Forest Context
		heath (Found in the cooler oceanic climate further north, where E. cinerea and Calluna are abundant) - H12 *Calluna vulgaris – Vaccinium myrtillus* heath (A sub-montane community found in upland regions in the north, with abundant Bilberry and Crowberry *Empetrum nigrum ssp. Nigrum*) - H16 *Calluna vulgaris – Arctostaphylos uva-ursi* heath (Found in the eastern Scottish Highlands) - H18 *Vaccinium myrtillus – Deschampsia flexuosa* heath (Abundant in the central and eastern Scottish Highlands at high altitudes) - H21 *Calluna vulgaris – Vaccinium myrtillus – Sphagnum capillifolium* heath (Found on more sheltered, humid slopes with a high cover of bog-mosses *Sphagnum spp.* and hypnaceous mosses, which are best-developed in Scotland) Dry heaths vary in their flora and fauna according to climate, and are also influenced by altitude, aspect, soil conditions (especially base-status and drainage), maritime influence, and grazing and burning intensity. They can support a number of rare plant and animal species. European dry heaths are found in every EU Member State except for Greece, but are only extensive in the western oceanic fringes of Europe. A high proportion the EU resource occurs in the UK and exhibit exceptional diversity in comparison with examples found elsewhere in the EU. They are particularly abundant in the UK in the uplands, where they may form extensive stands, which dominate the landscape. They are more localised in lowland areas, especially in south and central England.	
6410	***Molinia* meadows on calcareous, peaty or clayey-silt-laden soils (*Molinion caeruleae*)**	*Molinia* meadows are found mainly on moist, moderately base-rich, peats and peaty gley soils, often with fluctuating water tables. They usually occur as components of wet pastures or fens, and often form mosaics with dry grassland, heath, mire and scrub communities. This habitat type includes the most species-rich *Molinia* grasslands in the UK, in which purple moor-grass *Molinia caerulea* is accompanied by a wide range of associated species, including rushes, sedges and tall-growing herbs. The more impoverished forms of *Molinia* pasture on acidic substrates are excluded from the Annex I definition. In the UK these grasslands are represented by two NVC types: - M24 *Molinia caerulea – Cirsium dissectum* fen-meadow (The more widespread and diverse community with a heathy form. Found in south Wales, south-west England and Northern Ireland) - M26 *Molinia caerulea – Crepis paludosa* mire (Occurs more locally in wet grasslands	The New Forest represents *Molinia* meadows in southern England. The site supports a large area of the heathy form of M24 *Molinia caerulea – Cirsium dissectum* fen-meadow. This vegetation occurs in situations of heavy grazing by ponies and cattle in areas known locally as 'lawns', often in a fine-scale mosaic with Northern Atlantic wet heaths and other mire and grassland communities. These lawns occur on flushed soils on slopes and on level terrain on the floodplains of rivers and streams. The New Forest *Molinia* meadows are unusual in the UK in terms of their species composition, management and landscape position. The grasslands are species-rich, and a particular feature is the abundance of small sedges such as Carnation Sedge

SAC Annex I Habitat		Description	New Forest Context
		and fens in uplands and upland margins of northern England and north Wales. The vegetation has a distinctive sub-montane character.) Some *Molinia* meadows hold populations of notable species, including Whorled Caraway *Carum verticillatum*, Soft-leaved Sedge *Carex montana* and Marsh Fritillary Butterfly *Euphydryas aurinia.* This habitat type has a wide distribution in Europe and are widely but discontinuously distributed in Britain, with concentrations in south-west England, western and central Wales, East Anglia, northern England and the south-west of Northern Ireland.	*Carex panicea*, Common sedge *C. nigra* and Yellow-sedge *C. viridula ssp. oedocarpa*, and the more frequent occurrence of Mat-grass *Nardus stricta* and Petty Whin *Genista anglica* compared to stands elsewhere in the UK.
7150	**Depressions on peat substrates of the *Rhynchosporion***	This habitat occurs in complex mosaics with lowland wet heath and valley mire vegetation, in transition mires, and on the margins of bog pools and hollows in both raised and blanket bogs. The vegetation is typically very open, usually characterised by an abundance of White beak-Sedge *Rhynchospora alba*, often with well-developed algal mats, the bog moss *Sphagnum denticulatum*, Round-leaved Sundew *Drosera rotundifolia* and, in relatively base-rich sites, brown mosses such as *Drepanocladus revolvens* and *Scorpidium scorpioides*. The Nationally scarce species Brown Beak-sedge *Rhynchospora fusca* and Marsh Clubmoss *Lycopodiella inundata* also occur in this habitat. On lowland heaths in southern and eastern England this habitat is often associated with NVC type M21 *Narthecium ossifragum – Sphagnum papillosum* mire and occurs on humid, bare or recently exposed peat in three distinct situations: 1. in and around the edges of seasonal bog pools, particularly on patterned areas of valley mire, 2. in flushes on the edges of valley mires in heathlands, and 3. in areas that are artificially disturbed, such as along footpaths and trackways and in old peat-cuttings and abandoned ditches. In the north and west, within active raised bogs and blanket bogs, this habitat type is usually part of the transition between bog pools (NVC types M1 *Sphagnum auriculatum* bog pool community and M2 *Sphagnum cuspidatum/recurvum* bog pool community) and the surrounding bog vegetation (mainly M17 *Scirpus cespitosus – Eriophorum vaginatum* blanket mire and M18 *Erica tetralix – Sphagnum papillosum* raised and blanket mire). This habitat appears to be widely distributed in the EU, but is a rare habitat type in the	The New Forest is one of three sites selected in southern England for this habitat type and is considered to hold the largest area in England The depressions on peat substrates of the Rhynchosporion are found in complex habitat mosaics associated primarily with the extensive valley bogs of this site. The habitat type has developed in natural bog pools of patterned bog surfaces, in flushes on the margins of valley mires and in areas disturbed by peat-digging, footpaths, tracks, ditches etc. In places the habitat type is rich in brown mosses *Cratoneuron spp*. and *Scorpidium scorpioides*, suggesting flushing by mineral-rich waters. The mosaics in which this habitat type occurs are an important location for bog orchid *Hammarbya paludosa.*

SAC Annex I Habitat		Description	New Forest Context
		UK, exhibiting a narrow range of ecological variation and having a restricted, discontinuous geographical distribution.	
91D0	**Bog woodland**	In certain physical circumstances in the UK, scattered trees can occur across the surface of a bog in a relatively stable ecological relationship as open woodland, without the loss of bog species. This true Bog woodland is a much rarer condition than the progressive invasion of bogs by trees, through natural colonisation or afforestation following changes in the drainage pattern which eventually leads to the loss of the bog community. This habitat type has not previously been well described in the UK. A few examples of this unusual habitat type are found in areas of Scotland where summer drying may permit the establishment and growth of tree roots in the upper peat layers. The structure and function of this habitat type is finely balanced between tree growth and bog development. Tree growth, however, is always slow (or the trees would take over the bog); the trees are likely to be widely-spaced (because much of the surface area is too wet for them to establish), and dead trees may be common even among the fairly small individuals (because their weight depresses the peat locally leading to waterlogging and death). The trees are also often stunted. The principal tree species in this form of Bog woodland is Scots Pine *Pinus sylvestris*, with the community likely to be intermediate in character between NVC type W18 *Pinus sylvestris – Hylocomium splendens* woodland and more open mire types such as M18 *Erica tetralix – Sphagnum papillosum* mire or M19 *Calluna vulgaris – Eriophorum vaginatum* blanket mire. A birch *Betula spp.*-dominated variant of Bog woodland occurs where birch or willow *Salix spp.* occur in long-term stable combinations with bog vegetation. These birch/alder/willow types may be close to NVC type *W4c Betula pubescens – Molinia caerulea* woodland, *Sphagnum sub-community* or other wet woodland types, such as W2 *Salix cinerea – Betula pubescens – Phragmites australis* woodland or W3 *Salix cinerea – Galium palustre* woodland. Secondary birch woodland on degraded bogs, and woodland encroachment resulting from falling water tables, are excluded from the Annex I definition. Bog woodland is extensive in Fennoscandia but becomes increasingly rare through the lowlands of western Europe. True Bog woodland is thought to be widespread but rare in the UK, but current knowledge on the	Within the New Forest, in southern England, birch – willow stands occur over valley bog vegetation, with fringing Alder *Alnus glutinosa – Sphagnum* stands where there is some water movement. These stands appear to have persisted for long periods in stable association with the underlying *Sphagnum* bog-moss communities. The rich epiphytic lichen communities and pollen record provide evidence for the persistence of this association. The Bog woodland occurs in association with a range of other habitats for which The New Forest has also been selected a SAC.

SAC Annex I Habitat		Description	New Forest Context
		distribution and extent of this habitat type is limited.	
91E0	**Alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior* (*Alno-Padion, Alnion incanae, Salicion albae*)**	This habitat type comprises woods dominated by Alder and willow on floodplains in a range of situations from islands in river channels to low-lying wetlands alongside the channels. The habitat typically occurs on moderately base-rich, eutrophic soils subject to periodic inundation. Many such woods are dynamic, being part of a successional series of habitats. Their structure and function are best maintained within a larger unit that includes the open communities, mainly fen and swamp, of earlier successional stages. On the drier margins of these areas other tree species, notably Ash *Fraxinus excelsior* and Elm *Ulmus spp*., may become abundant. In other situations the Alder woods occur as a stable component within transitions to surrounding dry-ground forest (some of which are also Annex I woodland types). These transitions from wet to drier woodland and from open to more closed communities provide important ecological variation. The ground flora is varied. Some stands are dominated by tall herbs, reeds and sedges, for example Common Nettle *Urtica dioica*, Common Reed *Phragmites australis*, Greater Tussock-sedge *Carex paniculata* and Meadowsweet *Filipendula ulmaria*, while others have lower-growing communities with Creeping Buttercup *Ranunculus repens*, Common Marsh Bedstraw *Galium palustre*, Alternate-leaved Golden-saxifrage *Chrysosplenium oppositifolium* and Marsh-marigold *Caltha palustris*. In the UK this habitat falls mainly within the following NVC types: - W5 *Alnus glutinosa – Carex paniculata* woodland - W6 *Alnus glutinosa – Urtica dioica* woodland - W7 *Alnus glutinosa – Fraxinus excelsior – Lysimachia nemorum* woodland - W2a *Salix cinerea – Betula pubescens – Phragmites australis* woodland, *Alnus glutinosa – Filipendula ulmaria* sub-community Riparian trees are excluded from this habitat type except where these form part of a wider network of alluvial woodland and wetland communities. In general, these riverine and flush woods are widespread in Europe, but especially in the more intensively agricultural and long-settled lowlands they are much reduced in cover, often to just narrow strips or lines of trees. Clearance of riverine woodland has	The New Forest contains many streams and some small rivers that are less affected by drainage and canalisation than those in any other comparable area in the lowlands of England. Associated with many of the streams, particularly those with alkaline and neutral groundwater, are strips of Alder woodland which, collectively, form an extensive resource with a rich flora. In places there are examples of transitions from open water through reedswamp and fen to Alder woodland. The small rivers show natural meanders and debris dams, features that are otherwise rare in the lowlands, with fragmentary Ash stands as well as the Alder strips. In other places there are transitions to old acidophilous oak woods with *Quercus robur* on sandy plains and Atlantic acidophilous Beech forests with *Ilex* and sometimes also *Taxus* in the shrub layer (*Quercion robori-petraeae or Ilici-Fagenion*), for which The New Forest has also been selected as a SAC.

SAC Annex I Habitat		Description	New Forest Context
		eliminated most true alluvial forests in the UK; residual Alder woods frequently occur in association with other woodland types or with other wetland habitats such as fens.	
7230	**Alkaline fens**	Alkaline fens consist of a complex assemblage of vegetation types characteristic of sites where there is tufa and/or peat formation with a high water table and a calcareous base-rich water supply. The core vegetation consists of a mire with low-growing sedge vegetation of the following NVC types: - M9 *Carex rostrata – Calliergon cuspidatum/giganteum* mire - M10 *Carex dioica – Pinguicula vulgaris* mire - M13 *Schoenus nigricans – Juncus subnodulosus* mire At most sites there are well-marked transitions to a range of other fen vegetation types, predominantly, but not exclusively, to M14 *Schoenus nigricans – Narthecium ossifragum* mire and S24 *Phragmites australis – Peucedanum palustre* tall-herb fen in the lowlands. Alkaline fens may also occur with various types of swamp (such as species-poor stands of Great Fen-sedge *Cladium mariscus*), wet grasslands (particularly various types of *Molinia* grassland) and areas rich in rush species, as well as fen carr and, especially in the uplands, wet heath and acid bogs. There is considerable variation between sites in the associated communities and the transitions that may occur. Such variation can be broadly classified by the geomorphological situation in which the fen occurs, namely: floodplain mire, valley mire, basin mire, hydroseral fen (i.e. as zones around open waterbodies) and spring fen. Another important source of ecological variation is altitude, with significant differences between lowland fens, which are rich in southern and continental species, and upland fens, which are rich in northern species. A significant proportion of the alkaline fens surviving in the EU are believed to occur in the UK and Sweden. In the UK they occur over a widely scattered geographical range, but are unevenly and locally distributed, with important concentrations of the habitat in East Anglia, in northern England, and on Anglesey in north Wales. Alkaline fen vegetation has declined dramatically in the past century in the UK, and in many parts of the country only small, fragmentary stands survive.	No information is available on the distribution and status of alkaline fens in the New Forest SAC.
7140	**Transition mires and quaking bogs**	The term 'transition mire' relates to vegetation that in floristic composition and general ecological characteristics is transitional between acid bog and alkaline fens, in which the surface conditions range	No information is available on the distribution and status of transition mires and quaking bogs in the New Forest SAC.

SAC Annex I Habitat		Description	New Forest Context
		from markedly acidic to slightly base-rich. The vegetation normally has intimate mixtures of species considered to be acidophile and others thought of as calciphile or basophile. In some cases the mire occupies a physically transitional location between bog and fen vegetation, as for example on the marginal lagg of raised bog or associated with certain valley and basin mires. In other cases these intermediate properties may reflect the actual process of succession, as peat accumulates in groundwater-fed fen or open water to produce rainwater-fed bog isolated from groundwater influence. Many of these systems are very unstable underfoot and can therefore also be described as ‘quaking bogs’. Transition mires and quaking bogs can occur in a variety of situations, related to different geomorphological processes: in floodplain mires, valley bogs, basin mires and the lagg zone of raised bogs, and as regeneration surfaces within mires that have been cut-over for peat or areas of mineral soil influence within blanket bogs. The following NVC types form the core of transition mire vegetation in the UK: - M4 *Carex rostrata – Sphagnum recurvum* mire - M5 *Carex rostrata – Sphagnum squarrosum* mire - M8 *Carex rostrata – Sphagnum warnstorfii* mire - M9 *Carex rostrata – Calliergon cuspidatum/giganteum* mire - S27 *Carex rostrata – Potentilla palustre* tall-herb fen. However, this list is not exhaustive: forms of M2 *Sphagnum cuspidatum/recurvum* bog pool community, M14 *Schoenus nigricans – Narthecium ossifragum* mire and M29 *Hypericum elodes – Potamogeton polygonifolius* soakway are also important components on some sites. M21 *Narthecium ossifragum – Sphagnum papillosum* valley mire is excluded from the Annex I definition, as it is not transitional in a successional sense or in terms of its soil chemistry. Not all examples of M9 *Carex – Calliergon* mire belong to this Annex I type; where it occurs in more base-rich conditions or in association with other rich fen communities, it may be referable to alkaline fens, or, in stands where Great Fen-sedge is dominant, to calcareous fens with *Cladium mariscus*. Transition mires and quaking bogs have a wide European distribution but appear to be relatively scarce in the Mediterranean	

SAC Annex I Habitat		Description	New Forest Context
		region. In the UK they are a widespread but local habitat type that is ecologically variable and occurs in a wide range of geomorphological contexts.	

3 SSSI Unit Background

3.1 Geology and Soils

3.1.1 Solid (Bedrock) Geology and Structure

Geologically, the New Forest lies within the Hampshire Basin, a sedimentary basin containing strata of Tertiary age (Melville and Freshney, 1982). The bedrock beneath the Forest consists of interbedded sands, gravels, silts and clays belonging to the Lambeth, Thames, Bracklesham, Barton and Solent Groups (Table 3-1). Although they are classified as bedrock, these deposits are generally relatively soft (Smith, 2006). Underlying the Tertiary strata are rocks belonging to the Upper Cretaceous Chalk Group (Table 3-1).

The structural geology of the Tertiary rocks is relatively simple. In general the strata dip at a low angle (up to about 2.5°) to the southeast, south or southwest (Edwards and Freshney, 1987; Bristow *et al*., 1991; Barton *et al*., 2003). The oldest rocks are exposed in the north-western part of the area, and the youngest are exposed in the southeast. There are some gentle anticlinal and synclinal folds affecting the Tertiary strata, with axes trending east-west or northwest-southeast; these are related to structures in the underlying Mesozoic rocks (Edwards and Freshney, 1987). 1:50,000 geological mapping by the BGS shows only one fault mapped within the Tertiary strata of the New Forest: a north-south trending fault close to Denny Bog and Penny Moor, near Beaulieu (BGS DiGMapGB-50).

3.1.2 Superficial (Drift) Geology

Across large parts of the New Forest the Tertiary and older rocks are covered by superficial (drift) deposits of Quaternary age. The oldest superficial deposits were deposited during the Pleistocene Epoch. The youngest were deposited during the Holocene Epoch, which continues to the present day.

The Pleistocene saw dramatic climatic oscillations, with glacial periods alternating with warmer interglacials. During the glaciations, glaciers advanced across much of England, although they did not reach the area now occupied by the New Forest (Edwards and Freshney, 1987). The fact that the ice did not reach the area explains the absence of glacial till (boulder clay), a poorly sorted deposit dumped by melting glaciers. However, the area was influenced indirectly by the glaciers: head deposits (see Section 3.1.2.1) formed under periglacial conditions and glacial meltwater rivers transported vast quantities of sand and gravel (Bristow *et al*., 1991). The rivers were often graded to base levels different to modern sea level (Bristow *et al*., 1991), and so their deposits are preserved as river terraces above the modern floodplains.

The Holocene saw the deposition of alluvial deposits in river valleys, and also the local accumulation of peat.

3.1.2.1 Head

Head consists mainly of weathered material that has moved downhill by solifluction, a process in which waterlogged sediment moves slowly down-slope. Solifluction is particularly characteristic of periglacial environments where the spring/summer thaw gives rise to a saturated mobile layer of weathered material (broken up by freeze/thaw action) overlying an impermeable layer of permafrost. Other processes also contribute to head formation, including soil creep and the accumulation of wind-blown material, and some head may represent in situ regolith (Edwards and Freshney, 1987; Bristow *et al*., 1991; Barton *et al*., 2003).

As head is largely locally-derived, its lithology depends on the nature of the up-slope source material. In general it consists of poorly sorted clay, silt, sand and gravel (Edwards and Freshney, 1987; Barton *et al*., 2003). In the Southampton area the head is "typically a yellowish brown to orange-brown, silty clay or clayey sand, commonly with scattered angular flints." (Edwards and Freshney, 1987, p.78)

A thin skin of head (commonly < 1 m) covers most of the Tertiary Formations in the area, although this is not shown on published geology mapping (Edwards and Freshney, 1987). The published mapping shows head to be concentrated within valleys and on valley slopes. The minimum mapped thickness of head is 1 m; 2 to 3 m is typical and up to 5 m not uncommon (Barton et al., 2003).

3.1.2.2 River Terrace Deposits

River terrace deposits occur at a number of levels from about 0.5 to 100 m above the present-day floodplains (Barton *et al*., 2003). They consist mainly of sandy flint gravel, although finer material (silt and clay) is also present, especially in the upper parts of terraces (Edwards and Freshney, 1987; Bristow *et al*., 1991; Barton *et al*., 2003). In the Ringwood District, most river terrace deposits consist of an upper layer of gravelly sandy clay (typically about 0.8 m thick) overlying 1 to 2 m of mixed sand and gravel with a gravel base (Barton *et al*., 2003). Bedding within river terrace deposits is locally disrupted, reflecting cryoturbation ("frost churning" due to freezing and thawing) (Edwards and Freshney, 1987).

River terrace deposits are widespread within the New Forest. They commonly occupy the higher ground and interfluves, with the valley bottoms being floored by modern alluvium. Head deposits commonly blanket the slopes between the river terraces and modern floodplains.

3.1.2.3 Alluvium

Alluvial deposits occur along streams and river valleys. These deposits may consist of clay, silt, sand and/or gravel. In the Ringwood District, alluvium typically consists of up to 2.5 m of silt and clay (commonly organic or peaty) overlying a thin layer of "suballuvial" gravel (Barton *et al*., 2003). The alluvial sequences of the smaller streams of the Southampton District commonly consist of a layer of silty clay and clayey sand (up to 1.5 m thick) overlying a layer of sand and flint gravel (up to 1.5 m thick) (Edwards and Freshney, 1987).

3.1.2.4 Peat

The distribution of peat appears from the survey to be relatively poorly mapped within the New Forest. Within the survey, peat deposits were rarely observed to be over 0.5 m thick and the majority was less than 0.3 m thick. The thickest deposits were observed within valley basins.

Table 3-1: Stratigraphy of the New Forest and Surrounding Area

Age	Group	Formation	Member/ other	Description	Thickness
Quater-nary			Alluvium	CLAY, SILT, SAND and GRAVEL.	Up to 10 m
			Peat	Peat	
			River terrace deposits	CLAY, SILT, SAND and GRAVEL.	
			Head	CLAY, SILT, SAND and GRAVEL.	
Tertiary (Eocene)	Solent Group	Headon Formation / Headon Hill Formation		Greenish grey shelly CLAY with laminated SAND, SILT and CLAY.	Up to 49 m
			Lyndhurst Member	Greenish grey CLAY and fine-grained SAND with thick-shelled molluscs.	12 – 13 m
	Barton Group	Becton Sand Formation		Yellow/buff fine- to very fine-grained well sorted SAND.	6 – 70 m
			Becton Bunny Member	Grey/brown shelly CLAY.	0 – 8 m
		Chama Sand Formation		Greenish grey fine- to very fine-grained and rather clayey/silty SAND; slightly glauconitic. Also sandy CLAY.	6 – 15 m
		Barton Clay Formation		Greenish grey to olive grey, glauconitic CLAY; may contain fine-grained sand and shells (mainly bivalves and gastropods).	26 – 80 m
	Bracklesham Group	Selsey Sand		Fine-grained SAND, sandy SILT and sandy	0 – 50 m

Age	Group	Formation	Member/ other	Description	Thickness
		Formation		CLAY; locally shelly and glauconitic.	
		Boscombe Sand Formation		Fine- to medium-grained SAND with local pebble beds.	0 – 25 m
		Branksome Sand Formation		Fine- to coarse-grained, commonly lignitic, sand with lenticular CLAY beds.	0 – 70 m
		Marsh Farm Formation		Laminated CLAY, and SAND with clay laminae.	0 – 25 m
		Earnley Sand Formation		Green, glauconitic, clayey, silty fine-grained SAND and sandy SILT.	0 – 25 m
		Wittering Formation		Laminated CLAY, and SAND with clay laminae.	0 – 57 m
		Poole Formation		Fine- to very coarse-grained (locally pebbly) cross-bedded, commonly lignitic, SAND. Interbedded with pale grey to dark brown, carbonaceous, lignitic and (commonly) laminated CLAY. Red-stained structureless clay and silty clay present locally.	25 – 110 m
	Thames Group	London Clay Formation		Brownish grey to grey, sandy to silty CLAY. Also clayey and sandy SILT and silty SAND. Commonly glauconitic. Thin beds of flint pebbles present locally.	30 - 115 m
			Whitecliff Sand Member	Fine- to medium-grained cross-bedded SAND, locally pebbly.	0 – 21 m
Tertiary (Palae-ocene)	Lambeth Group	Reading Formation		Grey (usually red-stained) CLAY passing in places into coarse-grained cross-bedded SAND. Local clay-breccia, and pebble beds. Partly glauconitic.	0 – 45 m
Cret-aceous	Chalk Group (White Chalk Subgroup)	Portsdown Chalk Formation		White CHALK with scattered flints.	
Sources: BGS digital 1:50,000 geology mapping, Melville and Freshney (1982), Edwards and Freshney (1987), Bristow *et al*. (1991), Jones *et al*. (2000), Barton *et al*. (2003), and Neumann *et al*. (2004).					

3.1.3 Soils

Table 3-2 describes the Soil Associations present within the sites of interest. Most of the soils are prone to seasonal waterlogging due to the presence of slowly permeable subsoil layers or pans (Smith, 2006; Allen, 2005). Many of the soils are susceptible to poaching and structural damage during the winter (Smith, 2006). Poaching is the physical breakdown of soil structure under load causing compaction, for example from the passage of animals or vehicles.

Table 3-2: Soils of the New Forest Wetland Sites

Soil Association Code	Soil Association	Description	Distribution
571s	Efford 1	Argillic brown earths. Well-drained fine loamy soils, often over gravel. Associated with similar permeable soils variably affected by groundwater.	Developed on river terrace gravels in the southern part of the area.
572j	Bursledon	Stagnogley argillic brown earths. Deep fine loamy soils with slowly permeable subsoils and slight seasonal waterlogging. Associated with deep coarse loamy soils variably affected by groundwater. Some slowly permeable, seasonally waterlogged, loamy over clayey soils. Landslips and associated irregular terrain occur locally.	Developed on Tertiary clay. Present along the western edge of the New Forest, and also in the area between Lyndhurst and Ringwood.
631c	Shirrell Heath 1	Sandy-humo-ferric podzols. Well-drained, very acidic, sandy soils with a bleached subsurface horizon. Some similar soils with slowly permeable subsoils and slight seasonal waterlogging. Some sandy and coarse loamy soils affected by groundwater, often with a humose surface horizon. Droughty in the summer.	Developed on Tertiary sand. Present in the south-western part of the area.
643a	Holidays Hill	Naturally very acidic stagnogley-podzols. Sandy over clayey and loamy over clayey soils, locally with humose or peaty surface horizons. Slowly permeable subsoil layers/pans and slight seasonal waterlogging. Some very acidic well-drained sandy soils, and some deep sandy soils (affected by groundwater) with humose surface horizons. Vulnerable to poaching and compaction in winter. In the winter there may be standing water on level sites.	Developed on Tertiary sand and clay.
643c	Bolderwood	Naturally very acidic stagnogley-podzols. Coarse loamy over clayey soils with a bleached subsurface horizon. Slowly permeable subsoils and slight seasonal waterlogging. Vertical water movement impeded by subsoil pans and other slowly permeable layers. Local development of humose or peaty surface horizons (these are vulnerable to erosion). Some shallow, very flinty, soils. Excess winter rain ponds on surface and is absorbed slowly, but there is little runoff.	Developed on river terrace deposits. Located on the higher ground.
711g	Wickham 3	Typical stagnogleys. Slowly permeable, seasonally waterlogged, fine loamy over clayey and coarse loamy over clayey soils, and similar more permeable soils with slight waterlogging. Some deep coarse loamy soils affected by groundwater. In the New Forest the soils often have thin humose surface horizons. Landslips and associated irregular terrain occur locally. Waterlogged for long periods during the winter, but moderately droughty in the	Developed on Drift over Tertiary clay. Very widespread in the New Forest.

Soil Association Code	Soil Association	Description	Distribution
		summer. Poaches easily.	
711h	Wickham 4	Slowly permeable, seasonally waterlogged, fine loamy over clayey and fine silty over clayey soils associated with similar clayey soils, often with brown subsoils.	Developed on Drift over Tertiary clay. Present in northern and central areas.
841b	Hurst	Argillic gley soils with coarse loamy horizons. Coarse and fine loamy permeable soils mainly over gravel. Waterlogged by groundwater for much of the winter, but can be droughty in summer.	Developed on river terrace gravels.
841d	Shabbington	Argillic gleys. Deep fine loamy and fine loamy over sandy soils variably affected by groundwater (but tend to be affected by high water levels). Some slowly permeable, seasonally waterlogged, fine loamy over clayey soils.	Developed on river terrace deposits.
Too small to be mapped by the Soil Survey of England and Wales (1983)	Peat	Fibrous or semi-fibrous peat with raw un-decomposed surface layers.	Peat soils occur in many valley bottoms. They tend to occur within the Holidays Hill and Wickham Associations, and also on seepage steps at the boundary of the Bolderwood and Wickham Associations.
Notes: Sources: Soil Survey of England and Wales (1983), Smith (2006) and Allen (2005). *Stagnogley soils are slowly permeable, seasonally waterlogged, soils sometimes called "surface water gleys".			

3.2 Hydrogeology

3.2.1 Bedrock

Table 3-3 summarises the bedrock hydrogeology.

3.2.1.1 Chalk

The Chalk is a Principal (formerly Major) Aquifer of strategic importance for water supply in southern England (Allen *et al*., 1997; Environment Agency website). It has a high intergranular porosity, but the small size of the pores means that the hydraulic conductivity of the matrix is very low (~10^{-4} m/d) (Allen *et al*., 1997). However, the Chalk contains fractures, and these impart a high permeability. Most groundwater flow takes place within the upper 50 m of the aquifer, where fractures and bedding planes have been enlarged by solution (Allen *et al*., 1997).

Although the Chalk is often described as a dual porosity aquifer (with the intergranular pores providing storage and the fractures providing permeability), the small size of the intergranular pores means that they are not readily drained and that most of the effective storage is within the fracture network (Allen *et al*., 1997). As the fracture porosity is small, the specific yield is only about 1%, and the aquifer typically shows large seasonal fluctuations in groundwater level (Price, 1996). Groundwater levels may fluctuate by as much as 20 to 40 m during the course of a year (Jacobs, 2007).

3.2.1.2 Tertiary

In the present context, the most important hydrogeological units within the bedrock are the Tertiary Formations because they crop out within the New Forest, where they may exert a direct influence on watercourses and wetlands. Of these Formations, the Barton Clay and much of the London Clay are classified as non-aquifers and the other Formations are classified as Secondary A (formerly Minor) aquifers (Jones *et al*., 2000; Environment Agency website). The Secondary A classification includes "permeable layers capable of supporting water supplies at a local rather than strategic scale, and in some cases forming an important source of baseflow to rivers" (Environment Agency website).

As a whole, the Tertiary succession forms a multi-layered aquifer system in which the sand layers act as aquifers and the silt and clay layers as aquitards. The aquifer layers are often discontinuous as the sand layers pinch out, and may be hydraulically isolated from other permeable units (Neuman *et al*., 2004). Confined and semi-confined conditions are common, as are perched water tables (Neuman *et al*., 2004). Groundwater flow and storage within the Tertiary aquifers takes place mainly within the intergranular pore system. Where the basal Tertiary strata are permeable they are likely to be in hydraulic continuity with the underlying Chalk.

Aquifer properties within the Tertiary succession are highly variable. Jones *et al*. (2000) quote the following values for the Palaeogene (Palaeocene, Eocene and Oligocene) of the Hampshire Basin: transmissivity 1.1 to 1600 m^2/d with an arithmetic mean of 429 m^2/d and a geometric mean of 72.2 m^2/d (8 records); storage coefficient 0.00002 to 0.05 (6 records). Transmissivities of 50 to 100 m^2/d have been obtained from the Bracklesham Group where it is in hydraulic continuity with the Whitecliff Sands (Jones *et al*., 2000), and the Environment Agency employs an estimated regional transmissivity of around 20 m^2/d for the Poole Formation (Neumann *et al*., 2004). For the Becton Sand (Barton Group), transmissivities are estimated to be of the order of 50 to 100 m^2/d (Neumann *et al*., 2004). The storage coefficient is estimated as 0.02% where the Becton Sand is confined and 5% where it is unconfined (Neumann *et al*., 2004). Porosities of 29 to 40% have been recorded within the Palaeogene strata (Neumann *et al*., 2004).

Table 3-3 provides information about typical borehole yields and positions of spring lines. The information on yields is useful in the present context in that it provides an indication of permeability and indicates which layers are the main aquifer units. Springs and seepages are likely to occur at the base of sand units that overlie lower permeability silt and clay.

3.2.2 Superficial Deposits

The alluvium and river terrace deposits are classified as Secondary A Aquifers (Environment Agency website). Within these deposits, sands and gravels will act as aquifers, and silts and clays as aquitards. The head deposits are classified as Secondary Aquifers (undifferentiated); this means that they may include both permeable horizons (Secondary A Aquifers) and lower permeability layers that may store and yield limited amounts of groundwater (Secondary B Aquifers) (Environment Agency website). Where permeable drift deposits overlie Tertiary sands, the two are usually in hydraulic continuity (Bristow *et al*., 1991). Table 3-3 summarises the superficial hydrogeology.

Table 3-3: Hydrogeology of the New Forest and Surrounding Area

Age	Group	Formation	Member/ other	Hydrogeological Role	Water Resources
Quaternary			Alluvium	Aquifer / Aquitard	Yields from alluvium and terrace gravels are often obtained from the adjacent rivers.
			Peat	Aquifer / Aquitard	
			River terrace deposits	Aquifer / Aquitard Spring lines may be present at the base of high level river terraces.	
			Head	Aquifer / Aquitard	
Tertiary (Eocene)	Solent Group	Headon Formation / Headon Hill Formation		Aquifer / Aquitard	Sandy strata may provide yields sufficient for domestic or small agricultural use.
			Lyndhurst Member	Aquifer / Aquitard Confines underlying Becton Sand.	
	Barton Group	**Becton**		**Aquifer** The most	Yields up to 600 m^3/d in the

Age	Group	Formation	Member/ other	Hydrogeological Role	Water Resources
		Sand Formation		permeable and reliable aquifer within the Barton Group.	south; in the north they rarely exceed 200 m^3/d.
			Becton Bunny Member	Aquitard	Little useable groundwater
		Chama Sand Formation		**Aquifer**	May yield small supplies
		Barton Clay Formation		Aquitard	Little useable groundwater
	Bracklesham Group	Selsey Sand Formation		Aquifer / Aquitard Spring line at base	Variable lithology makes borehole yield hard to predict. Boreholes up to 200 mm in diameter may yield up to 200 m^3/d; boreholes over 400 mm diameter have yielded more than 1800 m^3/d from sandier strata. However, boreholes with little or no yield have been recorded.
		Boscombe Sand Formation		**Aquifer** Effectively a single multi-layered aquifer	
		Branksome Sand Formation			
		Marsh Farm Formation		Aquifer / Aquitard	
		Earnley Sand Formation		**Aquifer**	
		Wittering Formation		Aquifer / Aquitard	
		Poole Formation		Aquifer / Aquitard Spring line at base	
	Thames Group	London Clay Formation		Aquitard Springs common at base of sand layers.	Sandy beds may provide small yields of up to 100 m^3/d; initial yields often diminish with time.
			Whitecliff Sand Member	**Aquifer**	Yield up to 500 m^3/d.
Tertiary (Palae-ocene)	Lambeth Group	Reading Formation		Aquifer / Aquitard	Locally yields up to 200 m^3/d, although some of this water may come from the underlying Chalk. Usually yields less than 100 m^3/d. Boreholes may be dry where sands are thin or absent.
Cret-aceous	**Chalk Group (White Chalk Subgroup)**	**Portsdown Chalk Formation**		**Aquifer**	Principal Aquifer. Yields of 2000 m^3/d or more can be expected from boreholes of 300 mm diameter. However, borehole yields depend on the

Age	Group	Formation	Member/ other	Hydrogeological Role	Water Resources
					intersection of water-bearing fissures. Water quality generally good.
Sources: BGS digital 1:50,000 geology mapping, Melville and Freshney (1982), Edwards and Freshney (1987), Bristow *et al*. (1991), Jones *et al*. (2000), Barton *et al*. (2003), and Neumann *et al*. (2004).					

3.2.2.1 Water Quality

Different hydrogeological units will provide groundwater of different qualities to wetlands. The acidity of the groundwater is likely to have a strong impact on the type of vegetation and habitats. Allen (2005) states that:

- The river terrace deposits and tertiary sandy strata tend to be base-poor (or acidic),
- Headon Beds and Barton Clays tend to be more neutral.

The Headon Beds and Barton Clays are low permeability strata and therefore often are not a major source of water inputs to a system. This means that even where they underlie wetlands, acidic waters from higher more permeable layers are often the main source of water (and thus the main control on local water quality).

3.3 Background literature review - previous research and management of the New Forest

A review of available background literature has been undertaken to identify:

- Previous restoration projects / measures within the New Forest, and elsewhere that justify the selection of restoration measures in this project.
- Previous monitoring techniques both within and outside of the New Forest that could be utilised as part of the monitoring strategy for the SSSI sites assessed in this project.
- Previous monitoring results within the New Forest associated to restoration measures suggested for some of the SSSI units assessed in this project.
- Scientific literature that corroborates restoration measures and river typologies identified for the New Forest SSSI units.
- Constraints associated to some of the restoration techniques.

Table 3-4 provides a summary of the document reviewed, the comment within that document and the relevance of that comment to this study in respect of the above. A full reference list can be found at the end of this document.

Table 3-4: Literature review summary

Document	Comment	Relevance to this study
LIFE 2 (2001) – Securing NATURA 2000 objectives in the New Forest	Mechanical removal of rhododendron within Open Forest heathland. Removed bush and roots where possible.	Rhododendron identified as an invasive in this study of SSSI sites. Should now be manageable in annual programmes undertaken by the Forestry Commission. Sites seen to be impacted in this study should be communicated to the Forestry Commission.
LIFE 2 (2001) – Securing NATURA 2000 objectives in the New Forest	Conifer plantation removal was most successful where complete de-stumping was undertaken alongside infilling the artificial drains and a rake over the surface to level the ploughed ridge and furrow systems.	Conifer plantations have been identified as a pressure in this study and recommendations for removal have included removal and infilling of the artificial drainage network.

Document	Comment	Relevance to this study
LIFE 2 (2001) – Securing NATURA 2000 objectives in the New Forest	Bog woodland restoration involved removal of conifer plantations, artificial drain infilling and heather bale plugging.	Where artificial drainage networks and conifer plantations have been identified as a pressure in this study, recommendations have involved conifer removal and artificial drain infilling. Measures to raise water levels in main channels have included debris jam installation (where appropriate), channel bed raising and morphologic feature installation as these are seen to be more sustainable the heather bales plugs.
LIFE 3 (2006) – Sustainable wetland restoration in the New Forest	Initial geomorphological survey undertaken in Spring 2003 of Black Water and Highland Water identified significant modification, little natural recovery / restoration and a low frequency of debris dams in channelized / modified reaches	The surveys undertaken in this study have drawn similar conclusions with high levels of modification identified, low / dampened levels of natural recovery and low levels of debris jams in straightened / modified / deepened reaches where floodplain connectivity is poor.
LIFE 3 - Ober Water Geomorphological Dynamics Assessment	Straightening of the Ober Water as part of historic drainage activities, floodplain connection to riverine woodland has been lost and increased conveyance of material downstream had led to destabilisation. Restoration involved reinstating the palaeo channel to increase channel length and improved floodplain connectivity.	Where straightening, dredging and artificial modifications have been identified in this study and where palaeo channels have been identified, restoration of these channels has been recommended where appropriate. Improved floodplain connectivity in riverine woodland section has also been identified on several occasions with restoration measures including bed level raising, debris jams and morphological feature introduction and anastomosed channel encouragement.
LIFE 3	Restoration at Holmsley involved managing this incision within the stream through channel infilling and bed raising of up to 600mm using gravels, clay plugs and wooden steps. Surrounding drains were blocked using heather bales to reduce flow concentration into the main stream.	Similar restoration measures have been suggested for areas subject to incision identified in this study. Channel infilling using gravels and cohesive sediment berms (where appropriate) have been recommended to raise bed and water levels and restore floodplain connectivity.
LIFE 3	Restoration of tributary mires at Slufters involved using heather bales, clay plugs and spoil to manage incision associated to artificial drainage channels dug in the mid 19th Century.	Where incision has been identified as threatening mire sections, restoration measures have included using heather bales and cohesive sediment berms to manage knick points and channel infilling.
LIFE 3	Work at Dames Slough involved the restoration of 1.6km of deepened, straightened and embanked watercourse. The restoration included restatement of meanders, cutting of new meanders, installation of 10m clay plugs to divert water into palaeo channels, partial backfill of straightened channels leaving ponds where material	This restoration project includes numerous restoration techniques that have been recommended as part of this study where straightened, deepened and embanked watercourses require improvement.

Document	Comment	Relevance to this study
	amounts were insufficient and bed level raising using hoggin (mixture of gravels, clay and sand). This increased watercourse length and reconnected the floodplain. Deemed successful in the restoration of targeted wetland habitats.	
LIFE 3	Monitoring techniques used as part of the LIFE 3 project to determine response to restoration included discharge recorded to determine frequency of overbank flooding and impacts of improved floodplain connection on channel energy levels, field surveys of channel and floodplain habitats and biotope mapping and topographic survey. All undertaken pre and post restoration.	Some of these monitoring techniques have been employed as part of the restoration monitoring for the SSSI assessed for this study. This has been supplemented with more cost-effective approaches given the wide scale of the restoration. The LIFE 3 monitoring was at a detailed, relatively local scale making it unfeasible to use across all of the SSSI sites.
LIFE 3 - geomorphological monitoring	Monitoring results suggested that the restoration techniques used were successful in increasing floodplain wetting frequency and restoring geomorphic processes, debris jams have been successful in bed level raising and floodplain reconnection and incision management, debris jams had not significantly increased fine sediment deposition, flood peak travel time downstream reduced, improved floodplain connectivity and debris jams, semi-naturalisation has restored erosion and depositional processes. There was a short term increase in fine sediment levels post restoration as a result of the works.	The success of many of the restoration measures suggests those being recommended in this study are likely to achieve the objective of assisting natural recovery of the SSSI units.
LIFE 3	Ecological monitoring pre and post restoration suggested that short term declines in species diversity and abundance immediately after works would soon recover to pre restoration levels.	This provides confidence that short term disturbance created by the works will not impact ecological diversity in the long term.
LIFE 3	Fisheries survey indicated that river habitat had been increased as a result of restoring sinuosity but it was not possible to determine overall impact of fish abundance and diversity due to the short monitoring period. Recommendations for further future monitoring were provided.	Baseline fishery surveys may be required to determine likely impact and response of some of the restoration measures.
LIFE 3	Fixed point photography has been utilised by the Forestry Commission at three sites to record vegetation and	Both of these approaches have been suggested as part of the monitoring proposals for the restoration of the SSSI units

Document	Comment	Relevance to this study
	landscape change. Fixed point quadrats were also used to determine changes in vegetation communities.	assessed for this project. In addition, time lapse photography has been suggested which reduces costs in the long term associated to continued photo taking in the field.
RRC – Restoration at Warwickslade Lawn and Longwater Lawn, 2009 http://www.therrc.co.uk/case_studies/highland%20water%20at%20warwickslade%20lawn.pdf	5km of river restoration at Warwickslade Lawn SSSI and 1.5km at Longwater Lawn SSSI, to restore straightened, deepened channels and artificial drainage networks. Measures included reconnecting meandering palaeo channels, infilling / blocking 400m of straightened / deepened drainage ditches, reduce flow speeds to reduce bank erosion, hoggin and heather bales used for blocking.	Similar to the LIFE projects, this scheme utilises numerous approached recommended for the SSSI units assessed in this study including palaeo channel reconnection and artificial drain infilling and blocking.
Beechie, Sear et al. (2010) – Process based principles for restoring river ecosystems	Restoration of New Forest sites was process based and included restoring riffle pool processes and floodplain reconnection. It addressed root causes of degradation including incision and channelization, designing based on riparian species and initiating actions at the appropriate scale. Measures included blocking drainage channels, using wood structures at suitable jam points, removing non native trees.	Principles used in designing the restoration plans for the SSSI sites in this study have closely followed those suggested in this paper, including addressing issues at the root cause.
Gregory et al (1992) – coarse woody debris in stream channels in relation to river management in woodland areas	This study found that high densities of woody debris jams in New Forest streams have a significant impact locally on channel processes, floodplain wetting and channel migration.	Woody debris jams are a common restoration measure recommended in this study. This highlights their importance in terms of the flood regime and providing some dynamic channel stability to encourage anastomosed channel network creation.
Sear et al (2010) - Logjam controls on channel: floodplain interactions in wooded catchments and their role in the formation of multi-channel patterns	This paper determines the significant impact of log jams on channel and floodplain interaction and how they are important in the evolution and maintenance of multiple channel patterns in lowland river environments. Multiple channel networks can form rapidly following logjam formation. They significantly increase the frequency of overbank flooding and giving high rates of sediment accumulation in forested floodplain.	Woody debris dams have been frequently recommended as a restoration measure in this study to improve floodplain connectivity and to encourage anastomosed channel development across wooded floodplain areas. Palaeo channels provide evidence of this in numerous locations where they have become disconnected as a result of channel straightening, deepening and embanking.
HLS New Forest – Ditchend Brook	Restoration at Ditchend Brook included restoring the original meandering course and infilling the straightened channel.	Similar restoration approaches have been suggested in this study for sites where streams have been artificially straightened and steepened.
HLS New Forest – Fletchers Thorns	Restoration at Fletchers Thorns included restoring the	Similar restoration approaches have been suggested in this study for

Document	Comment	Relevance to this study
	artificially straightened channel (causing incision and reduced habitat diversity and poor floodplain connectivity) by restoring the original meandering section and channel infilling.	sites where streams have been artificially straightened and steepened.
Harwood and Brown (2006) - Fluvial processes in a forested anastomosing river: Flood partitioning and changing flow patterns	This paper discusses dynamics of anastomosing systems and highlights the important link to debris jams in the maintenance and evolution of these multi thread systems.	Debris jams and anastomosed system creation is a key component of several of the SSSI restoration plan measures. This provides scientific evidence to support the measure.
Nanson and Knighton (1996) – anabranching rivers: their cause, character and classification	For anastomosed systems to exist, there is a requirement for a flood-dominated flow regime and banks that are not prone to erosion, with local blocking to promote multi – branch development. Islands between channels are often permanent or semi-permanent and well vegetated.	Debris jams and anastomosed system creation is a key component of several of the SSSI restoration plan measures. This provides scientific evidence to support the measure.
Collins and Montgomery (2002) - Forest Development, Wood Jams, and Restoration of Floodplain Rivers in the Puget Lowland, Washington	Describes the importance and historic records of how wood jams were / are integral to maintaining an anastomosing channel pattern and a dynamic channel – floodplain connection. Historic clearance of trees and dams result in single thread channel creation. The continuing function of these systems is reliant on mature tree assemblages.	Debris jams and anastomosed system creation is a key component of several of the SSSI restoration plan measures. This provides scientific evidence to support the measure.
Denton (date unknown) - Assessment of potential effects of different grazing regimes in Wootton Coppice and Holmsley Inclosures.	Increasingly the over-grazing of the open forest is depleting invertebrate communities of richness. Precipitative action cannot be justified, and limited seasonal grazing is clearly the best approach accompanied by regular monitoring so that informed decisions can be made as to whether the density/timing needs to be modified.	This report begins to describe the impact of over-grazing on open forest communities. Over-grazing has been identified as an issue in some of the SSSI unit restoration plans.
Armstrong et al (2007) - Grip Blocking Best Practice Guide	Various recommendations for gulley and grip blocking are recommended based on erosion conditions, vegetation type, slope and soil type amongst others. Mitigation includes peat turve dams, heather bailing, plastic piling and wooden dams.	This paper highlights other suitable restoration measures, other than heather bailing, that could be used to infill gullies in mire and mire to stream transition units where energy conditions are appropriate.
Evans et al (2005) - Understanding gulley blocking in deep peat	This highlights similar measures to Armstrong et al (2007) and also notes the importance of suitable spacing of mitigating measures depending on the slope and level of erosion / incision.	Again highlights other suitable restoration measures for mire and mire to stream transition units where energy conditions are appropriate and how measures should be spaced to ensure sustainability.

As shown in Table 3-4, there is considerable evidence supporting many of the restoration measures proposed for the restoration of the SSSI units assessed in this project, including:

- The utilisation of woody debris jams and the process based approach to encouraging naturalisation through the use of these features.
- The encouragement of anastomosing channel types as part of the naturalisation process for some of the units.
- The infilling techniques for drain and tributary restoration.
- The use of fixed point photography for monitoring pre and post system change.

4 Geomorphological Assessment - Background

This section provides background information that has been identified and used within the geomorphological assessment to inform the conceptual models of the Geomorphological Assessment Areas and transition units and to help understand the types of rivers / streams and interventions that were observed during the field surveys. The information below is used within the classifications presented in the restoration plans for each SSSI unit.

4.1 Introduction

The streams of the new Forest are unusual in that their catchments are small enough to be entirely contained within the SSSI. Additionally they are characterised by a strong seasonal flow regime with significant winter flood peaks and a subdued summer baseflow (some channels are dry in the summer). This, coupled with the unique combination of nutrient-poor acid waters and outcrops of neutral-enriched soils and historic and contemporary land management practices, has allowed the development of a complex mosaic of interlinked habitats; alder, ash and oak woodland, bog woodland, wet and dry heath and grassland subject to winter waterlogging, valley bogs and seepages and riverine woodland often with an associated anastomosing channel network.

4.2 Geology and Soils

An overview of the geology and soils within the New Forest is given in section 3.1.

4.3 Land Use

Commoning is one of the dominant land use types within the New Forest where Commoners have historic rights to graze the land within the New Forest boundary (excluding inclosures). This practice is important for maintaining the mosaic of habitats within the New Forest SSSI, including the wet lawns.

4.4 Generic Character of the SSSI Units

The morphological units of the New Forest consist of valley floodplain and channel features which vary spatially. Within the Geomorphological Assessment Areas, there are a variety of river types with headwater areas often distinguished by overland flow collection points (mires in some cases) where dominant channels are sometimes difficult to identify. In some cases, historic drainage works have altered flow paths resulting in unnaturally high discharges into the river channel with the response of the river often being incision.

In most cases, the river / stream component of the SSSI unit becomes single thread downstream of the upstream collection point in the mire to stream transition units. The single thread sections fall into one of the following river types, wandering, active single thread (riffle - pool in some cases), plane bed and passive single thread. These are characterised by a variety of morphological features including pools, glides, runs, riffles, transverse bars, lateral bars, point bars, mid-channel bars, eroding banks, debris jams and backwaters,

Areas of lowland anastomosed reaches were identified, particularly through well connected, riverine woodland areas where networks of channels had developed between mature trees. The network of channels, in some instances, would only be activated at times of higher flows.

The associated floodplain displays in some cases palaeo-channels, floodplain backswamps and embankments (man-made). Historic and contemporary system management means that the majority of the out of channel features are also generally inactive or are evolving very slowly at present, with fluvial geomorphic processes having only a minimal impact on their morphology. This is because the floodplain (in some locations) has suffered some hydraulic and hydrological disconnection from the river, displaying only a partial link to river flow processes.

4.5 General geomorphological river character

Most of the single thread river / stream sections are active, particularly the wandering sections which are capable of moving significant amounts of gravel during elevated flows. Gravel supply is often from local bank and in-channel sources combined with significant upstream supply (Figure 4-1).

Figure 4-1: Local Gravel Supply

Some of the SSSI units are flashy (seen on site during heavy rainfall), therefore, sediment can be rapidly mobilised, transported and deposited as river water levels rise and fall. This is aided by limited fine sediment deposition within the channel which means gravels are unconsolidated and highly mobile, consequently vegetation establishment upon them is minimal.

Deposition of transported material is controlled by the flood energy and the local river morphology, resulting in preferential zones of sediment accumulation within the channel. This pattern of sedimentation and subsequent channel response, whilst creating local bank erosion and some loss of local floodplain, must be recognised as part of the naturalisation process continually being attempted by the river / stream, and such the gravel bar features created are likely to be integral components of a sustainable self-maintaining morphology for some of the SSSI units. Such zones are more common along the rivers / streams where it begins to flow across a wider floodplain, creating an incipient wandering gravel-bed channel exhibiting a high in-channel geomorphic diversity and associated habitat variety (see section 4.9). In some cases, this has led to the development of embryonic lowland anastomosed reaches where a sub-channel network has been created locally, often in riverine woodland units.

Where floodplain connectivity is poor, either as a result of channel straightening, embanking or dredging, bed incision is common, further disconnecting the river / stream from its floodplain and limiting in-channel gravel feature development. Drainage networks and tributaries within most of the SSSI units have been artificially created / modified and are often embanked, straightened and overdeepened resulting in incision and unnatural overland flow routes. This results in significant floodplain drying that impacts vegetation assemblages and flow concentration in the main channel and increasing incision.

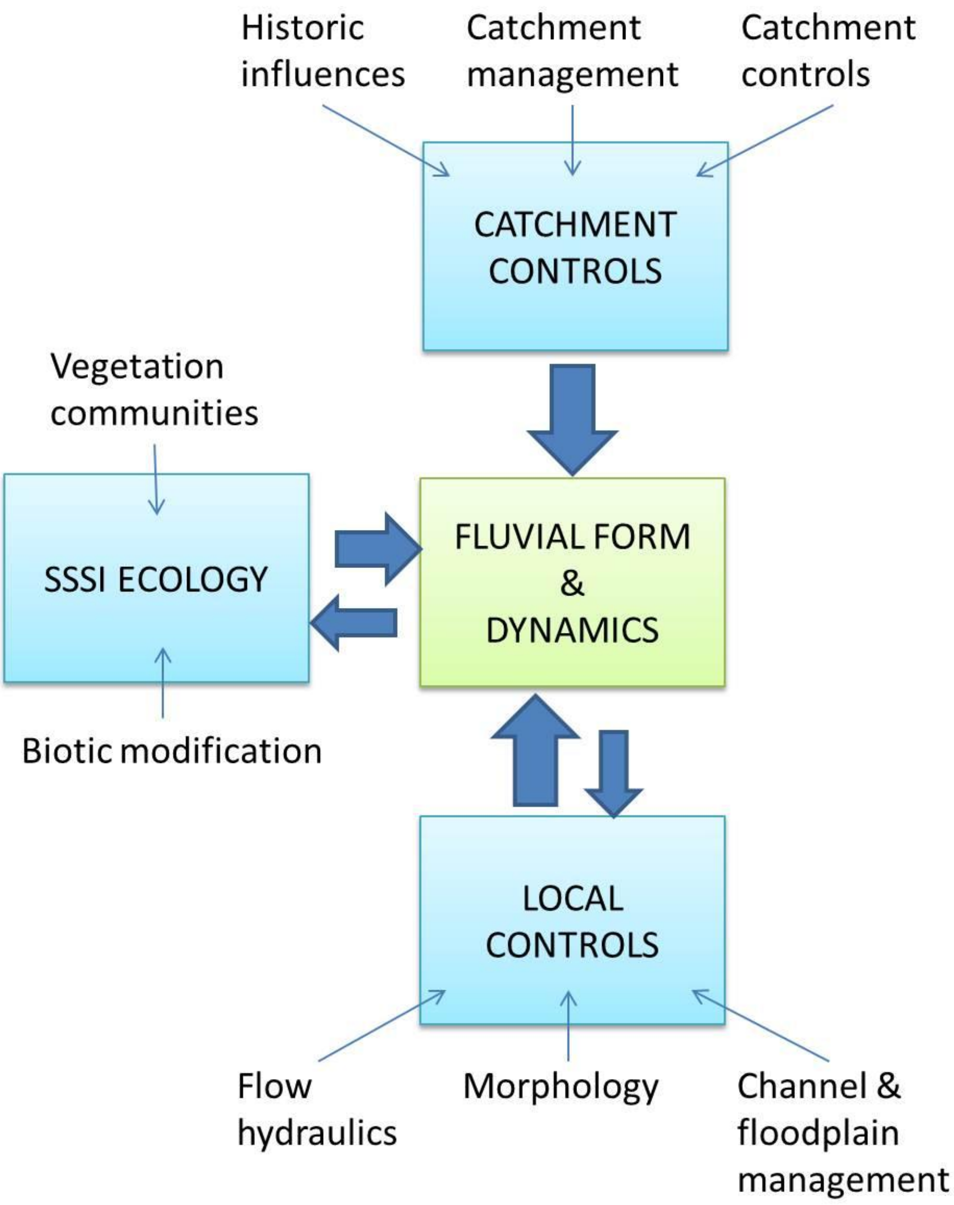
4.6 General controls on system functioning

In order to understand the form and function of the various Geomorphological Assessment Areas, it is necessary to identify controls on behaviour, highlighting patterns of channel change in response to multiple drivers. In order to achieve this, the following must be recognised:

- Catchment processes strongly influence system hydromorphology with process linkages occurring across sometimes large scales.
- In some locations, considerable modification has occurred to the system form and process both in the past and now. The system is responding to these modifications (e.g. drainage networks, commoning etc).
- The channel and floodplain must be treated as a single functional unit ensuring that channel and floodplain processes are restored together to create a sustainable dynamic naturalising system.
- Interactions occur between the hydromorphology (geomorphology, hydrology, hydraulics) and ecology to influence the present state and dynamics of the system.
- In most Areas, the system is both sensitive and dynamic and interventions and alterations to the form and process will invoke a reaction which must be both predictable and acceptable within the context of wider use of the river and catchment.

As such it is vital in this study to identify the process – behaviour linkages present in the catchment, identifying the controls on sediment movement and associated sedimentation and erosion along the watercourses (Figure 4-2).

Figure 4-2: Principal controls on the character and dynamics of the New Forest Geomorphological Assessment Areas



4.7 Sediment sources and sinks

4.7.1 Sediment sources

Generally, those Areas with significant gravel accumulations have a strong upstream and local sediment source, associated to:

- Erosion and movement of periglacial alluvial and sub-alluvial gravel
- Local bank sources
- Local accumulations of gravels
- Drain and tributary inputs - inputs from these are heightened where incision is occurring within the drainage network, often as a series of knickpoints migrating up the channels.

4.7.2 Sediment sinks

Gravel accumulations are frequent in several of the Geomorphological Assessment Areas within the New Forest, creating some wandering reaches, separated by often active, sinuous single thread channels. These sinks are continually evolving and new sink areas are also developing. This dynamic must be accounted for in any river / stream naturalisation plans.

4.8 Reach-scale characteristics of New Forest river types

Four principal river types have been identified in the Geomorphological Assessment Areas within the New Forest; lowland anastomosed, incipient wandering, active single thread and passive single thread. The distribution of each channel type is strongly linked with channel gradient, degree of modification (e.g. straightening which will be mapped), floodplain connectivity and sediment availability.

4.8.1 Lowland anastomosed

Lowland anastomosed reaches are often lower energy with a shallow gradient multi-thread channel network split by stable islands (often in the form of trees) and bars (Figure 4-3). The channel bed is often a mixture of gravels and fine sediments. The connectivity to the floodplain is good in these sections and is set in a wider valley. Some channels are activated at varying flow levels, with some dry during low flow levels. The formation is sometimes assisted by impoundment created by natural woody debris jams (live or dead). This river type has often been used as a target typology for some of the SSSI units as part of the restoration plan, as anastomosed networks are likely to be the natural river type for many of the streams visited, this is also discussed in the literature review, section 3.3.

Figure 4-3: Anastomosed river type within the New Forest SSSI

4.8.2 Wandering

Wandering reaches are characterised by a moderately steep gradient and by extensive gravelly deposits and active lateral movement. The channel is set in a wider valley but is often over-deep due to gravel removal / dredging and fluvial incision linked partly to the confinement of flood flows within over-deepened channels. The river is characterised by large gravel bars (point, mid and lateral) with occasional plane bed reaches and deeper pools (Figure 4-4).

Lateral movement is strong but localised and is intrinsically linked to bar deposition.

Figure 4-4: Wandering river type within the New Forest SSSI

4.8.3 Active single thread

This river type is less steep and is characterised by a gravelly bed, with a weakened gravel supply compared to the wandering river type. The channel is set in a wider valley but is often over-deep due to gravel removal / dredging and fluvial incision linked partly to the confinement of flood flows within over-deepened channels. The river displays stable riffle pool sequences with occasional plane bed reaches, point bars and lateral bars (Figure 4-5).

Lateral movement is restricted due to the reduced gravel presence and the reduced fluvial energy through these reaches and due to the presence of more resistant boulder clays in the banks rather than fluvio-glacial gravels, or where riparian woody vegetation is dense enough to provide a coherent resistant root mat.

Figure 4-5: Active single thread river type within the New Forest SSSI

4.8.4 Passive single thread

This river type is less steep than active single thread and is characterised by a mixed gravel and fine sediment bed (Figure 4-6). The channel is set in a wider valley but is often over-deep due to gravel removal / dredging and fluvial incision linked partly to the confinement of flood flows within over-deepened channels. Where bar deposits are present, these are poorly formed and flow types are dominated by glides with some runs. Lateral erosion is limited and where bank collapse has occurred, this is often a response to incision.

Figure 4-6: Passive single thread river type within the New Forest SSSI

4.9 Ecology

Within the Geomorphological Assessment Areas the ecological survey focussed primarily on the watercourses flowing through the units, with functional relationships between the geomorphology and ecology identified.

As a broad habitat generalisation, the watercourses within the Geomorphological Assessment Areas were generally located within woodland areas (e.g. Dockens Water Woods, Long Beech Enclosure) or in more open heathland/mire habitats, such as at Black Gutter Bottom and Cowleys Heath.

As discussed in section 4.5 above, within the woodland areas the streams were frequently of the lowland anastomosed type, with a network of channels contained within a boggy corridor of, in general, Grey Willow dominated woodland, with some Alder *Alnus glutinosa* and Downy Birch. Ground flora was often sparse, or moss dominated (Figure 4-3).

Being located in woodland areas these anastomosed watercourses were generally very shaded and contained significant quantities of leaf litter (Figure 4-7). As a result of the shading, aquatic macrophyte diversity was generally poor. Where the canopy was more open, species-richness increased, with patches of Floating Sweet-grass and Bog Pondweed abundant, with occasional Stream Water-crowfoot *Ranunculus pencillatus ssp. pencillatus*, Fool's Water-cress *Apium nodiflorum* and Water Forget-me-not *Myosotis scorpioides.* The riparian habitat of these more open areas was often heavily grazed and had a marshy grassland, closely cropped sward.

The wandering, active single thread and passive single thread river types were much less habitat specific, being variably recorded in both woodland and mire/heathland habitats. Where wandering, active or passive single thread watercourses were present within woodland areas the riparian habitat tended to be consistent in nature with the surrounding woodland habitat (Figure 4-7), predominantly being Oak and Beech *Fagus sylvatica* dominated pasture woodland, with an understorey of Holly. Although in places more wet woodland types were present with Alder and Grey Willow. Several of the watercourses, of all these types, also flowed through areas of plantation woodland (e.g. Amberwood/Alderhill). Again, due to the shading, aquatic macrophyte diversity was generally poor within these woodland watercourses.

Figure 4-7: Woodland streams in Islands Thorn/Amberwood (left) and Linford Bottom (right)

Along the woodland watercourses, of all types but primarily the lowland anastomosed channels, coarse woody debris jams were a key feature (Figure 4-8). In many cases these had a localised impact on the geomorphology of the stream and consequently created additional micro-habitats of interest.

Figure 4-8: Debris Jams in Dockens Water Woods (left) and Amberwood/Alderhill (right)

The streams within the more open, heathland and mire dominated units were generally of the wandering, active single thread or passive single thread type and showed an increased abundance of aquatic macrophytes in comparison with the woodland streams (Figure 4-9). This was particularly the case where the watercourses were shallower overland flow features, yet to become a distinct single thread feature. Creeping St. John's-wort and Bog Pondweed were the most dominant species, often present in very extensive patches. Other species recorded included Fennel Pondweed *Potamogeton pectinatus*, water-starwort species *Callitriche sp*., Purple Moor-grass tussocks and Floating Sweet-grass.

Figure 4-9: Mire/Heathland streams in Black Gutter Bottom (left) and Cowleys Heath Central (right)

Aquatic macrophytes were also particularly abundant in the more stagnant, ponded areas of streams, for example in areas where the banks had been significantly poached or around footbridges/trackways where water spread out over the floodplain in a localised area due to the impoundment created.

The riparian habitats of these mire/heathland streams were often varied, with grazed marshy grassland, wet heath and valley mire habitats the most frequent. The wet heath habitats tended to be dominated by Cross-leaved Heath and Purple Moor-grass, with some Heather, whereas the valley mire habitats were much more Purple Moor-grass dominated (Figure 4-9).

Within the higher energy systems, such as the wandering river type and to a lesser extent the active single thread type, active gravel reworking limited aquatic and wetland plant diversity, in addition to the shading created in the woodland areas. In-channel vegetation was extremely sparse, with the high energy and gravel movements preventing species colonising. Similarly, vegetation colonisation of the in-channel bar features was also limited, again due to the active and frequent inundation and remobilisation of the gravels.

4.10 Key Generic Pressures

4.10.1 Fine sediment and other pollutant supply from diffuse sources

Fine sediment inputs to the majority of the New Forest Geomorphological Assessment Areas appear to be within acceptable limits appropriate to the functioning of this system with little evidence of fine sediment choking of river gravels.

4.10.2 Fine sediment and other pollutant supply from point sources

There are some areas where local bank instability, modified drainage input and grazing / poaching are supplying fine sediments to some localised areas of the rivers / streams. This has resulted in patchy gravel bed degradation, particularly where livestock access the channel, but at a catchment scale, fine sediment is readily transported through the system and water quality is good.

4.10.3 Flow regime alteration

Drainage and channel modification has intensified the flow regime in some locations resulting in intensified flow levels within the main channel, often leading to incision and degradation of floodplain habitat associated to drying.

4.10.4 Channel straightening / realignment

Many of the watercourses within the Geomorphological Assessment Areas displayed evidence of straightening (Figure 4-10) during the survey with various palaeo-channels identified. These have also been identified in aerial photography and from the LiDAR. Areas may have responded by cutting down into the bed rather than by eroding laterally, particularly where bank cohesion is strong. Often the straightening occurred to maximise utilisable land in the valley bottom, creating a channel following one edge of the valley bottom and infilling or cutting of the original channel.

Figure 4-10: Example of significant channel straightening within the New Forest

4.10.5 Channel training

Channel training and protection presence is low within the Geomorphological Assessment Areas, with only small lengths in few places, mainly to protect road infrastructure.

4.10.6 Gravel removal / dredging

There is significant evidence of gravel removal and dredging within the main channels and in the drainage networks throughout the New Forest, which was mostly undertaken to lower the water table locally, improve capacity and reduce floodplain wetting (associated to commoning). Where this is no longer regularly occurring, gravel features are returning (Figure 4-11) and deposition alongside bank erosion can be seen in numerous locations.

Figure 4-11: Gravel bed recovery

Where groundwater levels have been lowered due to the bed degradation, further disconnection of floodplain palaeo-features has occurred and is impacting on floodplain habitats. This has resulted in the creation of many heavily grazed, wet lawn areas adjacent to watercourses in several places.

4.10.7 Embankments

Low level embankments occur along some of the rivers / streams within the Geomorphological Assessment Areas, and are very common along the network of drains (Figure 4-12). These are created from dredged material associated to channel straightening and capacity enhancement. These are creating channel incision through reducing floodplain connectivity (resulting in higher in-channel energy levels where flood flows are no longer spread across the floodplain), floodplain drying and ponded areas where overland flow routes into the main channel have been blocked.

Figure 4-12: Typical embankments within the New Forest

4.10.8 Floodplain management

Current and historic floodplain practices have significantly altered the natural habitats and vegetation on the floodplain, with riparian character seriously altered. Commoning is also reducing bank cohesion as root networks do not mature, meaning banks are more susceptible to erosion. This promotes the wandering river typology seen in numerous locations.

Poaching can also have a particularly significant impact in localised areas as a result of increased fine sediment inputs to the stream network.

4.10.9 Limited connection between floodplain and river

Connectivity between the river and the floodplain is poor in numerous locations throughout the New Forest, with the flood inundation and groundwater regime adversely affected. Key opportunity areas exist for reconnection, particularly where incision is a primary driver (Figure 4-13).

Figure 4-13: Example incision where floodplain connectivity has been reduced

4.10.10 Recreational Pressures (trackways)

In several locations watercourses are crossed by trackways, footpaths and bridges. In several locations the construction of crossing points across the watercourses has resulted in an impediment to flow, causing water to pond and spread out over the floodplain in localised areas, significantly impacting upon the habitats present in these areas. This was noted as a particular problem on Soldiers Bog where upstream of the bridge the unit was depositional as a result of the impounding influence of the bridge, and downstream erosional as a result of the disruption to the natural flow and sediment regime (see Figure 4-14). Flow regime alteration and ditching are also common pressures associated to the installation of crossing points.

Figure 4-14: Trackway causing localised ponding of water on Soldiers Bog

4.11 Generic Restoration Opportunities

4.11.1 Floodplain reconnection and incision management - debris jams, heather bailing, cohesive berms, embankment removal

Floodplain reconnection is only viable at sites where bed incision has not left the current bed too low to achieve an appropriate flooding regime. Some of the benefits and constraints to floodplain reconnection are shown in Table 4-1.

Table 4-1: Benefits and constraints associated to floodplain reconnection

Benefits	Constraints
Encourages anastomosing channel development. Reduces fine sediment inputs and fine sediment choking. Slows gravel movement. Stabilises in-channel features. Reduces floodplain drying impacts on vegetative assemblages.	Some restoration measures may require import of significant amounts of material. Local land use constraints may prevent suitable level of connection being attained.

Debris jams - are naturally occurring features (Figure 4-15) in several locations and would be a preferred option in the riverine woodland section. The literature review (section 3.3) has identified numerous examples of where woody debris jams have been successfully utilised (both in the New Forest and elsewhere) to reconnect the floodplain and to provide some stability to allow multi - thread (anastomosed) channels to form. These features are fundamental to the functioning and maintenance of these anastomosed systems and where examples of this were encountered during the site work, woody debris jams (live or dead) were nearly always present. The success of anastomosed channel networks is also reliant on the succession of these features, not just isolated occurrences, therefore naturally forming woody debris jams should not be removed from the channel. Where debris jams are recommended as a restoration measure in the unit restoration plans, they should be set into the banks locally to ensure they remain stable in the long term. Felling of local bankside trees could also be undertaken, leaving the root connection to the banks to reduce the risk of future failure and to encourage regrowth and further stabilisation of the dam.

Channel morphology restoration - in some instances, floodplain reconnection could be achieved through morphologic feature introduction to raise bed and water levels locally, possibly alongside debris jam installation where appropriate. The types of morphologic feature introduction are dependent on local processes, but in the wandering and active single thread river types this is likely to involve gravel features such as point bars, lateral bars, transverse bars and riffle - run - pool sequencing on the channel bed. Care must be taken here to ensure that gravel supply from upstream and locally is sufficient to maintain the units as functional features. This is likely to be refined based on detailed future restoration plan development.

Heather bailing (Figure 4-16) - is currently being adopted in some locations and has had some success in the mire to stream transition sites to prevent upstream incision migration and to improve upstream floodplain wetting, although some of these were showing signs of degradation during the site visits and may not be a long term / sustainable option. This is particularly the case where high energy remains which continues to threaten the measure through continued undercutting.

Cohesive berms - these are recommended as restoration measures to improve floodplain connectivity and reduce incision in areas where there is no surrounding mature trees (ruling out woody debris jams as a naturalised restoration option) and where the channel bed is fine sediment dominated rather than gravel dominated. This ensures restoration measures are aligned to existing processes. Using cohesive deposits (planted with suitable vegetation to improve stability) are likely to provide a longer term option for improved floodplain connectivity, particularly in the mire to stream transition units where energy levels are lower and fine sediment deposition occurs under natural conditions. This restoration option is likely to require import of material.

Channel infilling - this is often recommended as an option to restore floodplain connectivity in some of the SSSI restoration plans where current connectivity levels are very low and where cohesive berm or debris jams installation in isolation is unlikely to improve connectivity to a sufficient level. Infilling material is likely to be composed of mixed material, i.e. clays, silts and gravels (hoggin) to provide some stability to the channel bed to prevent future incision. Gravels on their own as part of channel infilling or morphological feature introduction are only suggested where there is a continuing upstream and local supply, otherwise the features are likely to disappear.

There are numerous techniques available for filling incised and over-deepened drains that would be appropriate to the mire to stream transition sites where incision at the downstream end of the unit threatens to migrate upstream through knickpoint propagation. The techniques should be aligned to the energy levels to ensure sustainable measures are put in place. The restoration plans note the most applicable techniques for infilling and incision management dependent on the local conditions. Many of these are outlined in Armstrong et al (2007) and Evans et al (2005) and the most applicable to the lower energy New Forest units visited for this study include:

- Peat turve dams
- Plastic piling
- Wooden dams
- Heather bailing

Embankment removal - this would also be favoured where this is present, alongside stream / drain infilling where appropriate, to improve floodplain connectivity and restore a more naturally functioning flow and flood regime. These have often been created as a result of channel straightening and dredging in the past and embankment material could be utilised as part of the channel infilling option, particularly for raising drain bed levels. This is likely to be recommended alongside other restoration measures to raise channel bed and water levels where existing floodplain connectivity levels are low.

Figure 4-15: Debris jam example

Figure 4-16: Heather bailing example

4.11.2 Riparian margin enhancement, grazing pressure reduction

Some unstable reaches would benefit from riparian margin enhancement measures to provide some bank cohesion through root networks, to reduce fine sediment supply to the channel (through a buffer strip) and to reduce poaching in sensitive areas. This would also encourage stability required to maintain a naturalised anastomosed channel network where lateral stability is important in the maintenance and sustainability of this river type. The succession of woody debris jams to maintain anastomosed channel networks is also reliant on surrounding bankside trees providing material for natural debris jams formation.

Some SSSI unit restoration plans have identified areas where excessive grazing is impacting the condition of the SSSI unit ecologically. Grazing pressure reduction measures are likely to need to be refined based on detailed restoration plan development in the future based on local pressures and access requirements. However, measures could include fencing, cattle moving or shepherding. Some of the benefits and constraints associated to riparian margin enhancement and grazing pressure reduction are shown in Table 4-2.

Table 4-2: Benefits and constraints associated to riparian margin enhancement and grazing pressure reduction

Benefits	Constraints
Controls lateral movement by improving bank stability. Assists anastomosing channel development and maintenance. Creates riparian hydromorphic diversity. A buffer strip acts as fine sediment trap. Allows woody debris accumulation within the channel. Encourages riparian hydromorphic diversity.	Land use constraints associated to grazing rights. Lawn habitats are an important component of the mosaic of habitats across the New Forest.

4.11.3 Palaeo channel reconnection / anastomosing

The rivers / streams in some locations have either been artificially straightened or, occasionally, have avulsed over time leaving channel scars across the landscape. There is opportunity to reinstate old channel routes where artificial straightening has occurred and to activate other palaeo features (Figure 4-17) through flow diversion. The benefits and constraints associated to palaeo channel reconnection and anastomosing network creation are summarised in Table 4-3.

Table 4-3: Benefits and constraints associated to palaeo channel reconnection / anastomosing

Benefits	Constraints
Reduces fine sediment inputs and fine sediment choking. Slows gravel movement. Stabilises in-channel features. Reconnects the floodplain providing wetter conditions. Encourage woody debris jam formation. Restores channel length, reducing erosive pressures on the bed and banks.	May require significant local floodplain works depending on degree of infilling of palaeo channel. May also require local channel infilling or blocking that may require import of material. Short term disruption to gravel transfer downstream may cause bed disruption, but unlikely to result in significant impacts, when undertaken with appropriate mitigation. Minor, localised disturbance to species and habitats during works.

In some areas, there is opportunity to create multi-thread channel networks which many of the New Forest sites would have naturally been before human intervention. Opportunity for this is restricted to a few riverine woodland sites but in some cases, embryonic development of this river type can be seen where floodplain connectivity levels are currently good enough to maintain multi - thread system development. They are particularly common where numerous debris jams have naturally occurred within inclosures. Debris jams should be used as a natural restoration measures to restore anastomosed channel networks, possibly alongside some local channel infilling and bed raising and minor local floodplain works if necessary.

Palaeo channel reconnection has been recommended in the unit restoration plans where significant channels have been identified in the floodplain during the site visit, from aerial photography and from LIDAR. The location and suitability for reconnection may need to be determined as part of future detailed restoration plan development and recent JFLOW modelling for Unit 48 (Latchmore Brook) has helped to refine restoration plan proposals for palaeo reconnection. Reconnection is likely to be achieved through local floodplain works at the up and downstream ends of the palaeo channel to ensure bed levels are suitably aligned with the existing main channel. Works may also be required along the palaeo channel length depending on the degree of infilling. In some cases, palaeo channel reconnection may be achieved through local channel blocking (e.g. debris jams) of the main channel to raise bed and water levels to encourage flow into the palaeo channel. This will also maintain some flow within the existing channel, particularly where notable species / habitats exist in the current main channel, reducing the need for costly channel infilling.

Figure 4-17: Palaeo feature identification

4.11.4 Drain and tributary improvements

The majority of the drains and tributaries require improvements within the New Forest Geomorphological Assessment Areas. They are often straightened, dredged / over-deepened, incised and embanked as a result of land drainage associated to forestry and grazing practice. There are opportunities for drain infilling, embankment removal and incision management (e.g. debris jams, channel infilling, cohesive berm introduction). In many locations, where incision has been instigated within drains and tributaries as a result of incision in the main channel, incision and knickpoint propagation within the drain is also impacting independently of processes within the main channel. Therefore, restoration necessarily recommends management of incision in the main channel and within the drain / tributary channel in the restoration proposals as management of incision within the main channel alone is unlikely to result in significant improvements to the drain / tributary incision levels. Some of the benefits and constraints associated to drain and tributary improvement are shown in Table 4-4.

Table 4-4: Benefits and constraints associated to drain and tributary improvements

Benefits	Constraints
Reduces flood peaks and reduces incision pressures. Reduces fine sediment inputs. Slows gravel movement. Stabilises in-channel features. Restores a natural flow regime.	May require import of significant amounts of material depending on the level of incision / over-deepening. Must be undertaken alongside incision management in the downstream main channel, where applicable. Local land use may prevent complete infilling of the drainage network.

Drain infilling (depending on the level of incision / over-deepening) can utilise embankment material but is likely to require, in most instances, import of suitable material.

The site visits and LIDAR information have been utilised to identify the significant drainage modifications within the SSSI unit. Flow lines have been produced for each of the geomorphic units using the LIDAR to determine the level of artificial modification and to target key restoration areas.

4.11.5 Structure improvement / replacement

Within some of the SSSI unit restoration areas, local structures were identified as having an impact on the hydromorphic and ecological conditions of the channel and floodplain. This was mainly a result of the obstacle created by the structure and the influence this has on the flow and sediment regime. In some instances, footbridges across the stream and floodplain created impounded conditions locally, restricting natural flow routes and promoting deposition upstream whilst starving downstream areas of sediment, resulting in erosion. Small pipes under roads to convey flows also impacted the local flow regime by ponding flow upstream and concentrating flow at one point downstream of the road. Some of the benefits and constraints associated to structure improvement or replacement are shown in Table 4-5.

Table 4-5: Benefits and constraints associated to structure improvement / replacement

Benefits	Constraints
Removes pinch point. Restores a more natural flow and sediment regime through removal of an obstacle.	Depending on the structure requirements, it could be costly to replace some of the structures, particularly those that require works to structures under roads.

Recommendations for suitable structure modification / replacement have been made within the SSSI unit restoration plans. As an example, where small pipes are currently conveying flows under roads, recommendations have been made for replacement with a larger structure (e.g. concrete culvert) to reduce the flow regime impacts and to provide less of an obstacle to natural flow path routes.

4.11.6 Phased removal of forestry

Large areas of planted coniferous forests are impacting the local flow and sediment regime of both the channel and the local floodplain. This is through impacts associated to floodplain drying, which can lead to excess fine sediment run off into drains and main channels. Large coverings can also impact in-channel water temperature and flow quantity, quality and variability, particularly for low flow scenarios where significant drying can result in channels completely drying up in summer months. Some of the benefits and constraints associated to phased removal of forestry are shown in Table 4-6.

Table 4-6: Benefits and constraints associated to phased removal of forestry

Benefits	Constraints
Reduced risk of floodplain and channel drying. Improved hydromorphic diversity.	Some forestry will need to be maintained.

Benefits	Constraints
Lowered risk of in-channel fine sediment accumulation.	

Where this has been identified as a serious pressure within some of the SSSI unit restoration plans, recommendations for mitigation have centred around the phased removal of coniferous trees. This has been undertaken as part of other restoration projects within the New Forest, as discussed in section 3.3.

4.11.7 Small scale remediation measures

As each SSSI unit restoration plan has been developed, opportunities have been identified at a smaller local / targeted scale to improve local hydromorphic and ecological conditions. This has included:

- Identification of existing natural debris jams that should be maintained as part of restoration plan development.
- Recommendations for types of morphologic feature introduction as part of restoration plans e.g. gravel feature type and riffle - pool sequencing. This is likely to be refined as part of future detailed restoration plan development.
- Impacts associated to ponds and recommendations for restoration measures.
- Where monitoring of existing restoration measures should be undertaken due to identified degradation.
- Identification of pressures outside of SSSI unit boundaries that could impact the SSSI unit in the future e.g. incision propagation upstream.
- Local targeted bankside planting.

Recommendations have also been made for likely assessment requirements as part of future restoration plan development. This included Flood Risk Assessment requirements where restoration could result in an increased flood risk to local property / infrastructure, or an engineering assessment linked to structure modification / removal.

5 Geomorphic Monitoring Strategy

5.1 Background

A large number of monitoring approaches have been adopted across a range of river studies in the UK (Table 5-1). It is clear that many are inappropriate for monitoring the New Forest SSSIs due to a number of factors including expense, required monitoring intensity (spatial and temporal) and requirements not to damage the SSSIs. Some past monitoring approaches adopted within the New Forest for past restoration schemes include fixed point photography, river reconnaissance, water level and flow monitoring and biotope mapping and are discussed in the LIFE project documents (see section 3.3 for further information)

Table 5-1: Advantages and disadvantages of ecological/hydromorphic monitoring approaches for rivers

Monitored element	Monitoring approach	Advantages	Disadvantages
Hydromorphic processes	Hydromorphic audit	Cost effective Qualitative	Requires experienced assessor
	Flow monitoring	Valuable hydraulic data	Requires measurement across flow regime Spatial coverage should match process variability
	Gravel trapping	Provides data on sediment supply and transport	Costly, high maintenance
	Hydraulic measurement	Detail on local control on channel form	Requires measurement across flow regime Spatial coverage should match process variability
	Biotope mapping	Qualitative Detail on hydraulic habitat	Requires measurement across flow regime Requires experienced assessor
	Particle tagging	Detail on sediment movement	Spatial coverage should match process variability High loss rate
Hydromorphic form	Morphology survey	Detail on form and change	Spatial coverage should match process variability
	Erosion monitoring (pins)	Local quantification of bank line change	Spatial coverage should match process variability Impacts on physical integrity of the banks
	Accretion monitoring (mats)	Detail on out of bank sedimentation	Spatial coverage should match process variability
	Sediment measurement	Information on sediment character, change and flux Can be carried out as part of wider audit work	Spatial coverage should match process variability
	Aerial LIDAR survey	Extensive mapping Good precision Allows change quantification and mapping	Expensive Complex processing and interpretation
	Terrestrial LIDAR survey	Very detailed mapping High precision Allows change	Expensive Complex processing and interpretation

Monitored element	Monitoring approach	Advantages	Disadvantages
		quantification and mapping	
	Fixed point photography	No specialist skills required for data collection Qualitative	Labour intensive
	Time lapse photography	Qualitative Cost effective Clear temporal change evidence	Moderate processing levels Poor control of image quality over time
Vegetation change	Ecological audit	Qualitative Cost effective	Requires experienced assessor
	Phase I mapping	Cost effective Partially quantitative through comparison of mapped habitat areas	Partially qualitative Quantitative assessment limited by broad-scale habitat descriptions Requires experienced assessor
	Quadrat sampling	Quantitative species assemblage data	Spatial coverage should match community variability Labour intensive
	Fixed point photography	Qualitative No specialist skills required for data collection	Labour intensive Broad change only
	Time lapse photography	Cost effective Moderate processing levels Clear temporal change evidence Qualitative	Poor control of image quality over time Requires careful placement (other studies have hidden them in bird boxes and trees to prevent vandalism and theft).
	Fixed point aquatic macrophyte surveys	Quantitative species data	Requires experienced assessor Labour intensive Not focused on adjacent floodplain adaptation
	Aerial LIDAR	Extensive mapping Excellent to monitor flow routes	Expensive Complex processing and interpretation

5.2 Pre restoration monitoring

The unit based reports produced as a result of this project will form a baseline data set usable for the next two years after which geomorphic processes will potentially have altered conditions sufficiently to warrant a new reconnaissance survey to update the base data and interpretation.

5.3 Unconstrained geomorphic monitoring strategy

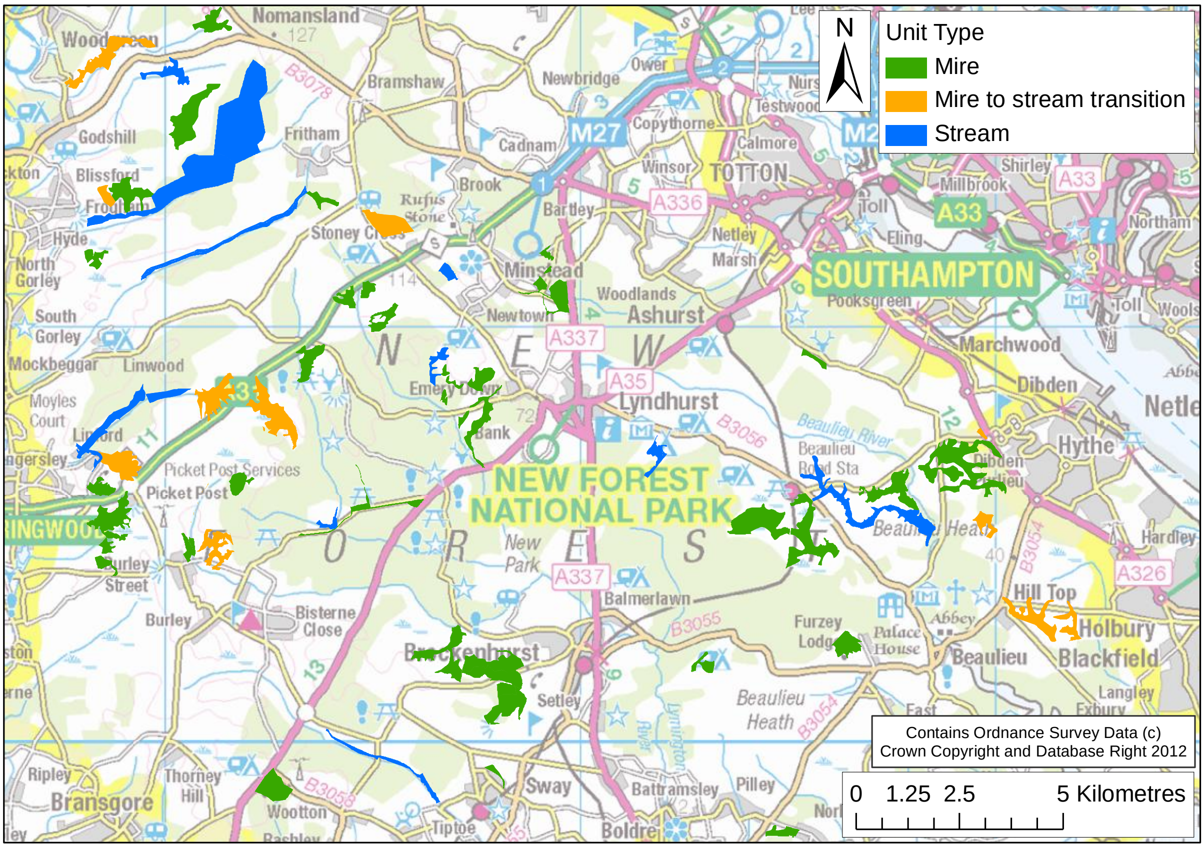
The table of monitoring approaches has been used alongside information gained from the site visits to recommend a set of assessment protocols appropriate for the entire New Forest. This is detailed in Table 5-2.

Table 5-2: Recommended monitoring approaches for the New Forest.

Generic monitoring approach		Cost	Method description
WITHIN SSSI UNIT SCALE (short term monitoring)	Time lapse photography	5 x £200 - camera cost £200 - Half yearly downloading Annual summary £300 Per site costs	Daily fixed point photographic capture (annual statistical summary) – to analyse morphologic unit change, flow change, sedimentology change and vegetation change.
	2 yearly reconnaissance	£500 per site Per site costs	Visual survey of study reach to determine reach scale change.
	Biennial Quadrat/aquatic macrophyte survey	£350-£500 - survey £500 - analysis Per site costs	Quadrat survey to determine vegetation change / response to restoration Aquatic macrophyte survey at fixed points to monitor vegetation change /response in streams
INTERACTING SSSI UNIT SCALE (Medium term)	5 yearly detailed hydromorphic and ecological audit	£1,000 per site	A combined audit similar to the level of detail for current study. Also assessing upstream and downstream connectivity outside of SSSI unit boundary
NEW FOREST SCALE (Long term)	10 yearly LIDAR assessment	~£50,000 for all study sites	Recapture of LIDAR data to assess catchment scale change and response to restoration, alongside detailed hydromorphic audit.

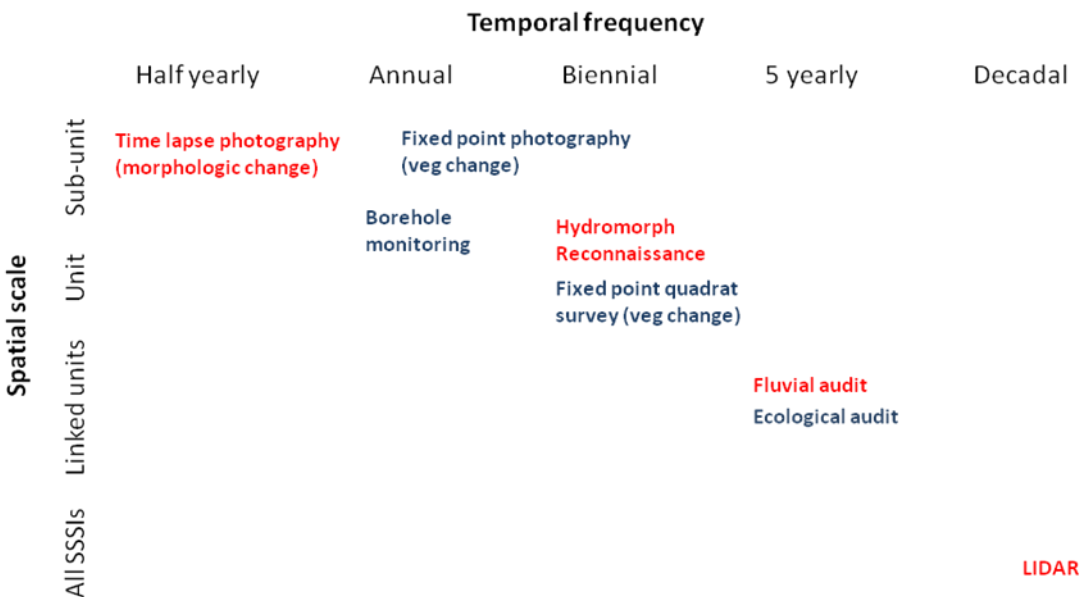
The protocol suggested in Table 5-2 and Table 5-3 is designed to monitor the geomorphic SSSI units illustrated in Figure 5-1. It necessarily targets key sites for detailed monitoring (section 5.4) whilst ensuring that all sites are reviewed both with regard to their internal integrity and their wider influence on linked SSSI and non-SSSI systems.

Figure 5-1: New Forest River and Mire SSSI units



The general dynamics of all the SSSI units should be assessed on a less frequent basis to ensure that their functioning is not deteriorating and rapid reconnaissance audits are suggested in combination with routine key site monitoring on a 2 yearly basis. The reconnaissance audits will include a biotope mapping component, to quantify process adjustment between 2 yearly audits. It is recognised that SSSI site restoration and response will influence linked systems and this should be assessed every 5 years using an approach similar to the combined ecological / hydromorphic assessment conducted for this project. Ten year LIDAR resurvey will allow whole system reassessment, looking in detail at channel and mire response and comparing flow path change over the decade. This approach is summarised in Figure 5-2 and Table 5-2 where generic costs are also given.

Figure 5-2: Spatial and temporal monitoring scales for the New Forest.



This spatially and temporally nested approach has been applied to the New Forest SSSI units with more frequent monitoring techniques suggested at key sites identified in the restoration reports (Table 5-3) and described further in section 6. The unit restoration plans provide explanation around the site specific monitoring proposals shown in Table 5-3 and Table 5-4.

Table 5-3: Shorter term monitoring at SSSI river sites across the New Forest.

Geomorphic Assessment Area	SSSI Units	Site Names	Requirements for monitoring
Lower Latchmore Brook	48	Latchmore Shade	Time lapse camera x5 Hydromorphic audit Fixed point camera survey Fixed point quadrat survey Fixed point aquatic macrophyte survey
Mid Latchmore Brook	66	Amberwood/Alderhill	Time lapse camera x5 Hydromorphic audit Fixed point camera survey Fixed point quadrat survey Fixed point aquatic macrophyte survey
Upper Latchmore Brook	540	Islands Thorns / Amberwood	Time lapse camera x5 Hydromorphic audit Fixed point camera survey Fixed point quadrat survey Fixed point aquatic macrophyte survey
Black Gutter	35	Black Gutter Bottom	Time lapse camera x2 Hydromorphic audit Fixed point camera survey Fixed point quadrat survey Fixed point aquatic macrophyte survey
Dockens Water	545	Dockens Water Woods	Time lapse camera x5 Hydromorphic audit Fixed point camera survey Fixed point quadrat survey Fixed point aquatic macrophyte survey
Suburbs Wood	75	Suburbs Wood Mire	Time lapse camera x2 Hydromorphic audit Fixed point camera survey Fixed point quadrat survey Fixed point aquatic macrophyte survey
Long Beech Inclosure	112	Long Beech	Time lapse camera x3 Hydromorphic audit Fixed point camera survey Fixed point quadrat survey Fixed point aquatic macrophyte survey
Linford Brook	88	Linford Bottom	Time lapse camera x5 Hydromorphic audit Fixed point camera survey Fixed point quadrat survey Fixed point aquatic macrophyte survey
Roe Inclosure South	117	Roe Inclosure South	Time lapse camera x3 Hydromorphic audit Fixed point camera survey Fixed point quadrat survey Fixed point aquatic macrophyte survey
Buckherd Bottom	95	Buckherd Bottom	Time lapse camera x3 Fixed point camera survey Fixed point quadrat survey Fixed point aquatic macrophyte survey
Picket Bottom	91	Picket Bottom	Time lapse camera x3 Hydromorphic audit Fixed point camera survey Fixed point quadrat survey Fixed point aquatic macrophyte survey
Bagshot Gutter	368	Wick Wood Riverine Woodland	Time lapse camera x5 Hydromorphic audit Fixed point camera survey Fixed point quadrat survey Fixed point aquatic macrophyte survey
The Knowles	341	Ma 5 Wet	Time lapse camera x2 Fixed point camera survey Fixed point quadrat survey Fixed point aquatic macrophyte survey
Corbet's Hat	341	Ma 5 Wet	Time lapse camera x2 Fixed point camera survey Fixed point quadrat survey

Geomorphic Assessment Area	SSSI Units	Site Names	Requirements for monitoring
			Fixed point aquatic macrophyte survey
West of Wood Crates	341	Ma 5 Wet	Time lapse camera x2 Fixed point camera survey Fixed point quadrat survey Fixed point aquatic macrophyte survey
Harvest Slade	126	Harvest Slade Bottom	Time lapse camera x5 Hydromorphic audit Fixed point camera survey Fixed point quadrat survey Fixed point aquatic macrophyte survey
Avon Water	539	Wootton Riverine Woodland	Time lapse camera x5 Hydromorphic audit Fixed point camera survey Fixed point quadrat survey Fixed point aquatic macrophyte survey
Fleet Water	286	The Grove	Time lapse camera x3 Hydromorphic audit Fixed point camera survey Fixed point quadrat survey Fixed point aquatic macrophyte survey
Cowleys Heath Central	423	Cowleys Heath Central	Time lapse camera x3 Hydromorphic audit Fixed point camera survey Fixed point quadrat survey Fixed point aquatic macrophyte survey
Cowleys Heath East	422	Cowleys Heath East	Time lapse camera x3 Hydromorphic audit Fixed point camera survey Fixed point quadrat survey Fixed point aquatic macrophyte survey
Park Hill Lawn	386	Park Hill Lawn (Pondhead)	Time lapse camera x2 Hydromorphic audit Fixed point camera survey Fixed point quadrat survey Fixed point aquatic macrophyte survey
Ferny Croft South	426	Ferny Croft South	Time lapse camera x2 Hydromorphic audit Fixed point camera survey Fixed point quadrat survey Fixed point aquatic macrophyte survey
Soldiers Bog	123	Soldiers Bog	Time lapse camera x2 Hydromorphic audit Fixed point camera survey Fixed point quadrat survey Fixed point aquatic macrophyte survey
Ma 5 Wet	341	Ma 5 Wet	Time lapse camera x7 Hydromorphic audit Fixed point camera survey Fixed point quadrat survey Fixed point aquatic macrophyte survey
Spring Wood Riverine Woodland	371	Spring Wood Riverine Woodland	Time lapse camera x3 Hydromorphic audit Fixed point camera survey Fixed point quadrat survey Fixed point aquatic macrophyte survey

An estimate has been made for the total cost of monitoring requirements, for each relative timescale, for the geomorphic SSSI units assessed for this project:

- 6 monthly - downloading time lapse camera data (all sites cost rather than per camera) = **£5,000**
- Annually - analysis of time lapse camera data (all sites cost rather than per camera) = **£7,500, ;**
- Biennially - 1) Fixed point quadrat / aquatic macrophyte survey = **£49,000** (assumed £500 survey cost per site at this stage); 2) Hydromorphic reconnaissance = **£10,500**
- 5 yearly - Fluvial audit (hydromorphic) = **£25,000**
- 10 yearly - LIDAR recapture = ~**£50,000** (assumed cost of £290 per tile)

Initial equipment costs - time laps cameras = **£19,200**

Table 5-4 illustrates a 35 year spend profile for the unconstrained monitoring approach described above for all geomorphic sites assessed and Table 5-5 provides total costs associated to these on a total and yearly basis.

Table 5-4: 35 year monitoring spend profile for the New Forest River SSSI units.

Time (years)	Time lapse and analysis		Reconnaissance	Fluvial audit	LIDAR
Initial camera outlay	12000				
0.5	5000				
1		7500			
1.5	5000				
2			10500		
2.5	5000				
3		7500			
3.5	5000				
4			10500		
4.5	5000				
5		7500			
5.5	5000			25000	
6			10500		
6.5	5000				
7		7500			
7.5	5000				
8			10500		
8.5	5000				
9		7500			
9.5	5000				
10			10500	25000	40000
10.5	5000				
11		7500			
11.5	5000				
12			10500		
12.5	5000				
13		7500			
13.5	5000				
14			10500		
14.5	5000				
15		7500		25000	
15.5	5000				
16			10500		
16.5	5000				
17		7500			
17.5	5000				
18			10500		
18.5	5000				
19		7500			
19.5	5000				
20			10500	25000	40000
20.5	5000				
21		7500			
21.5	5000				
22			10500		
22.5	5000				

Time (years)	Time lapse and analysis		Reconnaissance	Fluvial audit	LIDAR
23		7500			
23.5	5000				
24			10500		
24.5	5000				
25		7500		25000	
25.5	5000				
26			10500		
26.5	5000				
27		7500			
27.5	5000				
28			10500		
28.5	5000				
29		7500			
29.5	5000				
30			10500	25000	40000
30.5	5000				
31		7500			
31.5	5000				
32			10500		
32.5	5000				
33		7500			
33.5	5000				
34			10500		
34.5	5000				
35		7500		25000	

Table 5-5: Total geomorphic and ecological monitoring costs over 35 years

Scenario	Total cost	Cost / yr
Geomorphology	795500	22729
Geomorphology, no LIDAR	675500	19300
Geomorphology and ecology	795500	22729
Geomorphology and ecology, no LIDAR	675500	19300

5.4 Site prioritisation and basic survey strategy

Given financial constraints a reduced intensity monitoring strategy could be adopted centring on those sites identified in the unit audit reports as being significantly at risk with degraded system functioning and ecology (Table 5-6). This is also linked to the site prioritisation assessment in section 6. Only these sites would be subject to annual monitoring and analysis for other sites only assessed during 5 year audits

Table 5-6: Priority monitoring sites assessed as currently displaying degraded form, function and ecology.

Site name	Type	Site area	SSSI unit number	Requirements for monitoring
Latchmore Shade	River	23.4	48	Time lapse camera x5 Hydromorphic audit Fixed point camera survey Fixed point quadrat survey Fixed point aquatic macrophyte survey
Amberwood/Alderhill	River	126.5	66	Time lapse camera x5 Hydromorphic audit Fixed point camera survey Fixed point quadrat survey Fixed point aquatic macrophyte survey
Islands Thorns / Amberwood	River	195.3	540	Time lapse camera x5 Hydromorphic audit Fixed point camera survey Fixed point quadrat survey Fixed point aquatic macrophyte survey
Long Beech	River	43.6	112	Time lapse camera x3 Hydromorphic audit Fixed point camera survey Fixed point quadrat survey Fixed point aquatic macrophyte survey
Wootton Riverine Woodland	River	23.6	539	Time lapse camera x5 Hydromorphic audit Fixed point camera survey Fixed point quadrat survey Fixed point aquatic macrophyte survey
Harvest Slade Bottom	River	0.3	126	Time lapse camera x5 Hydromorphic audit Fixed point camera survey Fixed point quadrat survey Fixed point aquatic macrophyte survey
Wick Wood Riverine Woodland	River	14.4	368	Time lapse camera x5 Hydromorphic audit Fixed point camera survey Fixed point quadrat survey Fixed point aquatic macrophyte survey
Roe Inclosure South	River	15.8	117	Time lapse camera x3 Hydromorphic audit Fixed point camera survey Fixed point quadrat survey Fixed point aquatic macrophyte survey
Parkhill Lawn (Pondhead)	River	15.9	386	Time lapse camera x2 Hydromorphic audit Fixed point camera survey Fixed point quadrat survey Fixed point aquatic macrophyte survey
Picket Bottom	Transition	43.7	91	Time lapse camera x3 Hydromorphic audit Fixed point camera survey Fixed point quadrat survey Fixed point aquatic macrophyte survey
Linford Bottom	River	46.3	88	Time lapse camera x5 Hydromorphic audit Fixed point camera survey Fixed point quadrat survey Fixed point aquatic macrophyte survey
Dockens Water Woods	River	43.4	545	Time lapse camera x5 Hydromorphic audit Fixed point camera survey Fixed point quadrat survey Fixed point aquatic macrophyte

Site name	Type	Site area	SSSI unit number	Requirements for monitoring
				survey
Ferny Croft South	River	85	426	Time lapse camera x2 Hydromorphic audit Fixed point camera survey Fixed point quadrat survey Fixed point aquatic macrophyte survey
Cowleys Heath Central	Transition	41.3	423	Time lapse camera x3 Hydromorphic audit Fixed point camera survey Fixed point quadrat survey Fixed point aquatic macrophyte survey
Cowleys Heath East	Transition	18.8	422	Time lapse camera x3 Hydromorphic audit Fixed point camera survey Fixed point quadrat survey Fixed point aquatic macrophyte survey
The Grove	River	9.8	286	Time lapse camera x3 Hydromorphic audit Fixed point camera survey Fixed point quadrat survey Fixed point aquatic macrophyte survey
Black Gutter Bottom	River	23.5	35	Time lapse camera x2 Hydromorphic audit Fixed point camera survey Fixed point quadrat survey Fixed point aquatic macrophyte survey

Table 5-7 illustrates a 35 year spend profile for the basic monitoring strategy and priority sites and Table 5-8 provides total costs associated to this basic approach on a total and yearly basis.

Table 5-7: 35 year prioritised monitoring spend profile for the New Forest River SSSI units, basic approach.

Time (years)	Time lapse	Time lapse and analysis	Ecology	Reconnaissance	Fluvial audit	LIDAR
Initial camera outlay	12000					
0.5	2500					
1		4000				
1.5	2500					
2			30000	10500		
2.5	2500					
3		4000				
3.5	2500					
4				10500		
4.5	2500					
5			49000		25000	
5.5	2500					
6				10500		
6.5	2500					
7		4000	30000			
7.5	2500					
8				10500		
8.5	2500					
9		4000				
9.5	2500					
10			49000	10500	25000	40000
10.5	2500					
11		4000				
11.5	2500					
12			30000	10500		
12.5	2500					
13		4000				
13.5	2500					
14				10500		
14.5	2500					
15			49000		25000	
15.5	2500					
16				10500		
16.5	2500					
17		4000	30000			
17.5	2500					
18				10500		
18.5	2500					
19		4000				
19.5	2500					
20			49000	10500	25000	40000
20.5	2500					
21		4000				
21.5	2500					
22			30000	10500		
22.5	2500					
23		4000				
23.5	2500					

Time (years)	Time lapse	Time lapse and analysis	Ecology	Reconnaissance	Fluvial audit	LIDAR
24				10500		
24.5	2500					
25			49000		25000	
25.5	2500					
26				10500		
26.5	2500					
27		4000	30000			
27.5	2500					
28				10500		
28.5	2500					
29		4000				
29.5	2500					
30			49000	10500	25000	40000
30.5	2500					
31		4000				
31.5	2500					
32			30000	10500		
32.5	2500					
33		4000				
33.5	2500					
34				10500		
34.5	2500					
35			49000		25000	

Table 5-8: Total geomorphic and ecological monitoring costs over 35 years for basic approach

Scenario	Total cost	Cost / yr
Geomorphology	629000	17971
Geomorphology, no LIDAR	509000	14543
Geomorphology and ecology	1182000	33771
Geomorphology and ecology, no LIDAR	1062000	30343

The total yearly cost for this basic monitoring approach, assuming no LIDAR is flown every 10 years, is approximately £30,343. This cost should be read in conjunction with yearly costs calculated for the eco-hydrological monitoring approach in the eco-hydrological overview report.

6 Site Restoration Prioritisation

Following the development of the unit specific restoration plans, the geomorphic sites have been ranked to determine a prioritised restoration list for the assessed SSSI units, based on the following criteria:

1. General habitat improvement - this has been qualitatively scored based on the likely extent of overall habitat improvement for the SSSI unit.
2. Key species positively impacted - this has been qualitatively scored based on the likely impact to key species within the SSSI unit.
3. Key hydromorphic processes reinstated - this has been qualitatively scored based on the degree of restoration of the key hydromorphic processes associated to each SSSI unit, this could include improvement to incision levels, key feature restoration, palaeo channel reconnection, anastomosed channel encouragement etc.
4. Flood connectivity improved - this has been qualitatively scored based on the degree to which river and floodplain connectivity is likely to be improved, based on the proposed restoration measures, for each SSSI unit. This could be through debris jam installation, bed raising, channel infilling and embankment removal.
5. The severity of the current situation - this has been qualitatively scored based on degree of existing degradation to the SSSI unit from both a hydromorphic and ecological perspective.
6. The impact on floodplain land use - this has been qualitatively scored based on the level of impact on the existing floodplain land use, e.g. the impacts of more frequent wetting of the floodplain.
7. Cost of restoration - this has been scored based on the likely level of cost associated to the restoration measures for each of the unit restoration plans. No specific costs have been calculated but the anticipated degree of work associated to the restoration plan has been subjectively scored.
8. Site access issues - this has been qualitatively scored based on any identified access issues to the site to undertake the proposed restoration measures identified in the SSSI unit restoration plans.

Each criterion was scored from 1 to 4, with 1 being a low impact and 4 being a high impact.

The positive criteria (numbers 1 to 4 above) were then summed and the negative criteria summed (numbers 5 to 8 above) to give an overall score out of 16 for each. The negative score was then subtracted from the positive score to give an overall classification score to rank the sites. This gives an indication of the likely overall restoration outcomes for each sites and where the benefits associated to the restoration significantly outweigh the constraints.

A comparison has also been made to the prioritised list for restoration identified in the Forestry Commission HLS 10 year restoration plan. It is not known the criteria used for the Forestry Commission prioritised list.

The sites have been listed in Table 6-1 below based on the prioritisation determined for the purposes of this project, ordered from high priority (were benefits significantly outweigh the constraints) to low priority. Please treat this as a subjective exercise as no weighting of criteria has been undertaken. Those highlighted in green in the Forestry Commission Restoration Year column show a good agreement to the prioritisation determined for the purposes of this project and those in red where there is poor agreement.

Table 6-1: Ranked priority list for geomorphic SSSI unit restoration.

Site name	Site area	SSSI unit number	General habitat improvement	Key species positively impacted	Key hydromorphic process reinstated	Connectivity improved	POSITIVES	Severity of current situation	Impact on floodplain land use	Cost	Access issues	NEGATIVES	OVERALL SCORE	Forestry Commission Restoration Year
Parkhill Lawn (Pondhead)	15.9	386	4	4	4	4	16	3	3	2	2	10	6	2013/2014
Black Gutter Bottom	23.5	35	3	3	3	4	13	2	4	2	1	9	4	2012/2013
Islands Thorns / Amberwood	195.3	540	4	4	4	4	16	4	3	3	3	13	3	2017/2018
Amberwood/Alderhill	126.5	66	4	4	4	4	16	4	3	3	3	13	3	2014/2015
Latchmore Shade	23.4	48	4	4	4	4	16	4	3	3	3	13	3	2012/2013
Picket Bottom	43.7	91	3	3	3	3	12	3	2	2	2	9	3	Not listed
Wootton Riverine Woodland	23.6	539	4	4	4	4	16	4	3	3	3	13	3	2013/2014
Long Beech	43.6	112	4	4	4	4	16	4	4	3	3	14	2	2014/2015
Harvest Slade Bottom	0.3	126	4	4	4	4	16	4	4	3	3	14	2	2013/2014
Linford Bottom	46.3	88	4	4	4	4	16	3	4	4	3	14	2	2014/2015
Dockens Water Woods	43.4	545	4	3	3	3	13	3	3	3	3	12	1	2015/2016
Wick Wood Riverine Woodland	14.4	368	4	4	4	4	16	4	4	4	3	15	1	2016/2017
Ferny Croft South	85	426	3	4	3	4	14	3	4	4	2	13	1	2016/2017
Spring Wood Riverine Woodland	7.37	371	3	3	4	4	14	4	3	4	2	13	1	Not listed
Roe Inclosure South	15.8	117	3	3	4	3	13	4	3	3	3	13	0	Not listed
Cowleys Heath Central	41.3	423	3	3	3	3	12	3	3	3	3	12	0	2015/2016
Cowleys Heath East	18.8	422	3	3	3	3	12	3	3	3	3	12	0	2015/2016
The Grove	9.8	286	3	3	3	2	11	3	3	3	3	12	-1	Not listed

Colouring legend (overall score classification):

<0	Low priority
1 to 2	
2 to 3	
>4	High priority

There is a generally good agreement between the prioritised list developed for the purposes of this project (based on the criteria described) and the list produced by the Forestry Commission in terms of likely restoration years (over the next 10yrs). Those shown as not listed were not shown in the Forestry Commission Plan. It is likely that unit 540 does not show a good agreement between the two ranked lists as the linkage to the rest of the downstream Latchmore Brook units may not have been considered as part of the Forestry Commission criteria.

As a result of this analysis, this list can be used with confidence to prioritise sites when considering taking forward the unit specific restoration plans developed for this project.

7 Conclusion and recommendations

Unconstrained restoration plans have been developed for each of the geomorphic SSSI units based on information gathered during the audit work and other data analysis including LIDAR, aerial photography, historic and background information and scientific literature. This overview report should be read in conjunction with the unit specific restoration plans (see Annexes) to provide context and justification to the development of each plan.

A monitoring strategy has been produced for each unit and description of this has been provided in section 5 of this report. This includes pre and post restoration monitoring recommendations.

Where applicable, further assessments have been highlighted that are likely to be required as restoration plans are taken forward, refined and submitted for planning. This includes recommendations for Flood Risk Assessments and engineering assessments where structures are proposed for modification.

As restoration plans are developed through consultation and the planning process, changes and further detail are likely to be included before a final restoration design has been agreed. Further assessment of numerous sites could be refined and justified as part of further detailed audit work and fluvial modelling as undertaken for unit 48 that has provided further analysis and justification of proposed restoration measures that has led to refinement.

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Annexes A - R

Geomorphological Assessment Areas - Site Restoration Plans

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Registered Office
South Barn
Broughton Hall
SKIPTON
North Yorkshire
BD23 3AE

t:+44(0)1756 799919
e:info@jbaconsulting.com

Jeremy Benn Associates Ltd
Registered in England 3246693

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www.jbaconsulting.com