Natural England Commissioned Report NECR140

# New Forest SSSI Geomorphological Survey Overview

## Annex D: Linford Bottom Restoration Plan - SSSI Unit 88

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# 1 Linford Bottom Restoration Plan - SSSI Unit 88

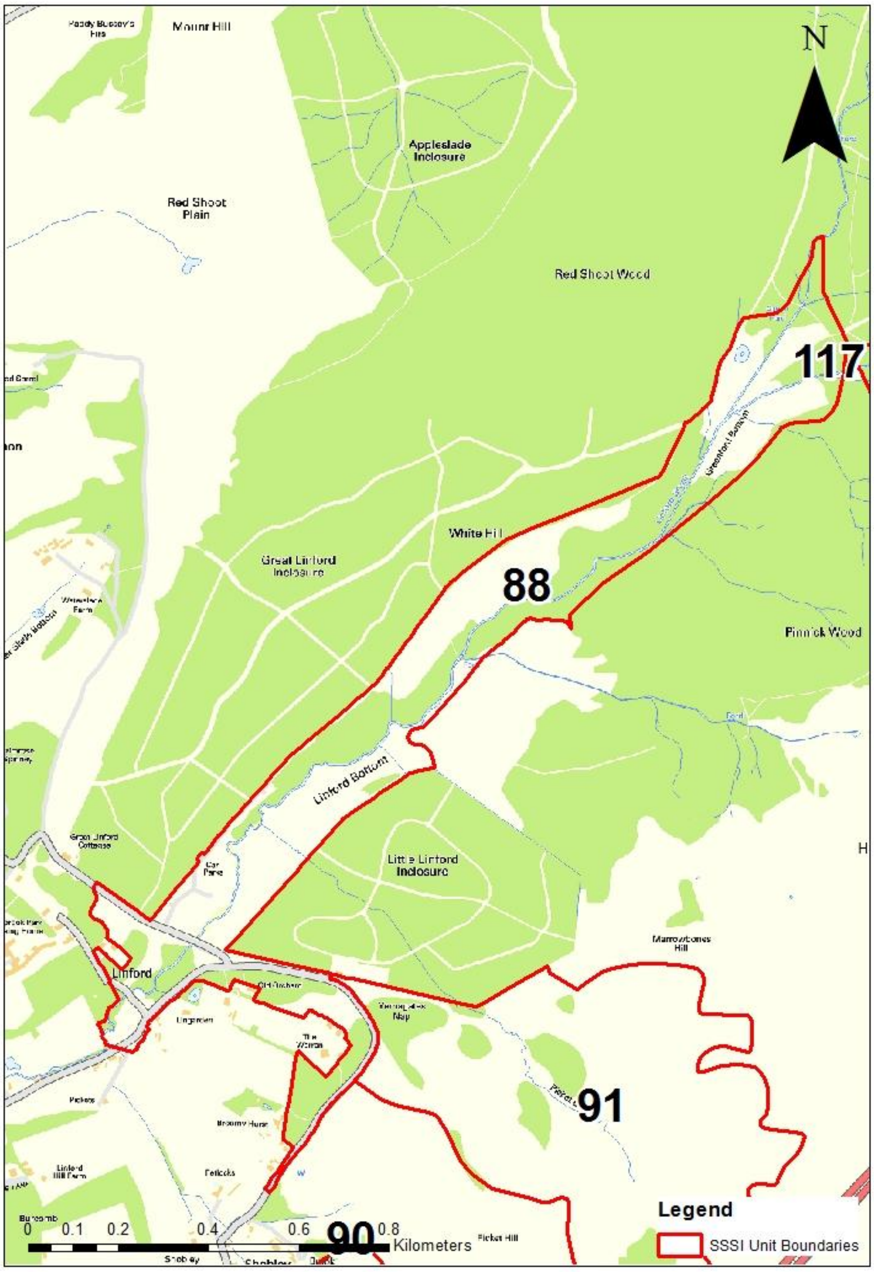
## 1.1 Introduction

Linford Bottom (Unit 88) is fed by Unit 117 at the upstream end and Unit 91 in the downstream reach (Figure 1-1). The SSSI unit is considered to be in unfavourable recovering condition. It is approximately 46.29ha in size.

The unit consists predominantly of broadleaved woodland, which is a mixture of bog and pasture woodland. Within the most northern and southern sections of the unit are areas of wet grassland. Within the central section of the unit, to the north of the watercourse there is an area of wet heath.

It is important to consider undertaking the proposed works within this unit alongside works for Unit 117 upstream as the incision within the upper sections of unit 88 is impacting the conditions within Unit 117 at the downstream end. Any works undertaken in Unit 117 risk being compromised in the future if this is not undertaken. Works within Unit 117 will also assist approaches suggested for Unit 88 in terms of flow regime impacts and flow naturalisation suggestions. Incision impacting the downstream Unit 91 is also linked to drainage incision issues in Unit 88, therefore works within Unit 91 should also be aligned with works to the drains in this unit to ensure the root cause of the incision is also managed alongside measures to manage the knick-point in Unit 91.

Figure 1-1: SSSI Unit 88 location (flow direction is north to south)






## 1.2 Current hydromorphic conditions and issues

A summary of the hydromorphic conditions of Unit 88 is given below in Table 1-1.

Table 1-1: Hydromorphic conditions of unit 88

| Geomorphological Assessment Area | | Linford Brook |
|---|---|---|
| Site name | | Linford Bottom |
| Size (ha) | | 46.3 |
| SSSI unit(s) | | 88 |
| Channel Condition | River type (s) | Weak lowland anastomosed, active single thread, plane bed |
| | Responsiveness | High - moderate gradient, straightening, strong gravel supply, tree clearance (historic) |

| | | |
|---|---|---|
| | Sediment delivery, type and mobility | Strong upstream and local gravel sources, mixed gravel fraction, very mobile, gravels in banks. Few fines |
| | Main source of water | Upstream source (Milkham Inclosure, Bratley Plain) and drains |
| | Aquatic vegetation | No in-channel vegetation present |
| | Drainage damage | Drains over both banks have been dug and are straight, minor incision, greater u/s |
| | Morphology | Pools, riffles, runs, chute channels, point bar, lateral bar, mid-channel bar, transverse bar |
| | Incision | Yes - d/s sections are ok but u/s more incised, reaction to straightening and embankments |
| | Engineering | Bank protection at d/s end close to road, channel straightening, some dredging |
| | Bank activity | Moderate, some lateral activity in active single thread sections. Some bank collapse associated to incision in u/s section |
| | Flow type (s) | Flows impacted by upstream and local drainage network. Flood peaks concentrated in channel where more incision. |
| Floodplain Condition | Valley type | Wide floodplain |
| | Main source of water | Drains / overland flow, out of bank flows |
| | NVC communities | W11, W10a/b, W1, M23a, M16a |
| | Key habitat types | Broadleaved woodland, Wet grassland, Wet heath, Bracken |
| | Drainage | Drains impacted by embankments and straightening. Natural drainage impacted through artificial drainage network. |
| | Scrub / tree encroachment damage | Gorse/scrub encroachment particularly on wet grassland areas |
| | Palaeo features | Yes - palaeo channels evident in both single thread and anastomosed sections throughout |
| | Floodplain connectivity | Good to moderate |
| | Poaching and grazing pressures | Significant grazing damage |
| Generic restoration options | | Reinstate palaeo channels, create more anastomosed sections in wooded areas, debris jams, embankment removal on drains and main channel (particularly at upstream end) |
| Additional comments | | |

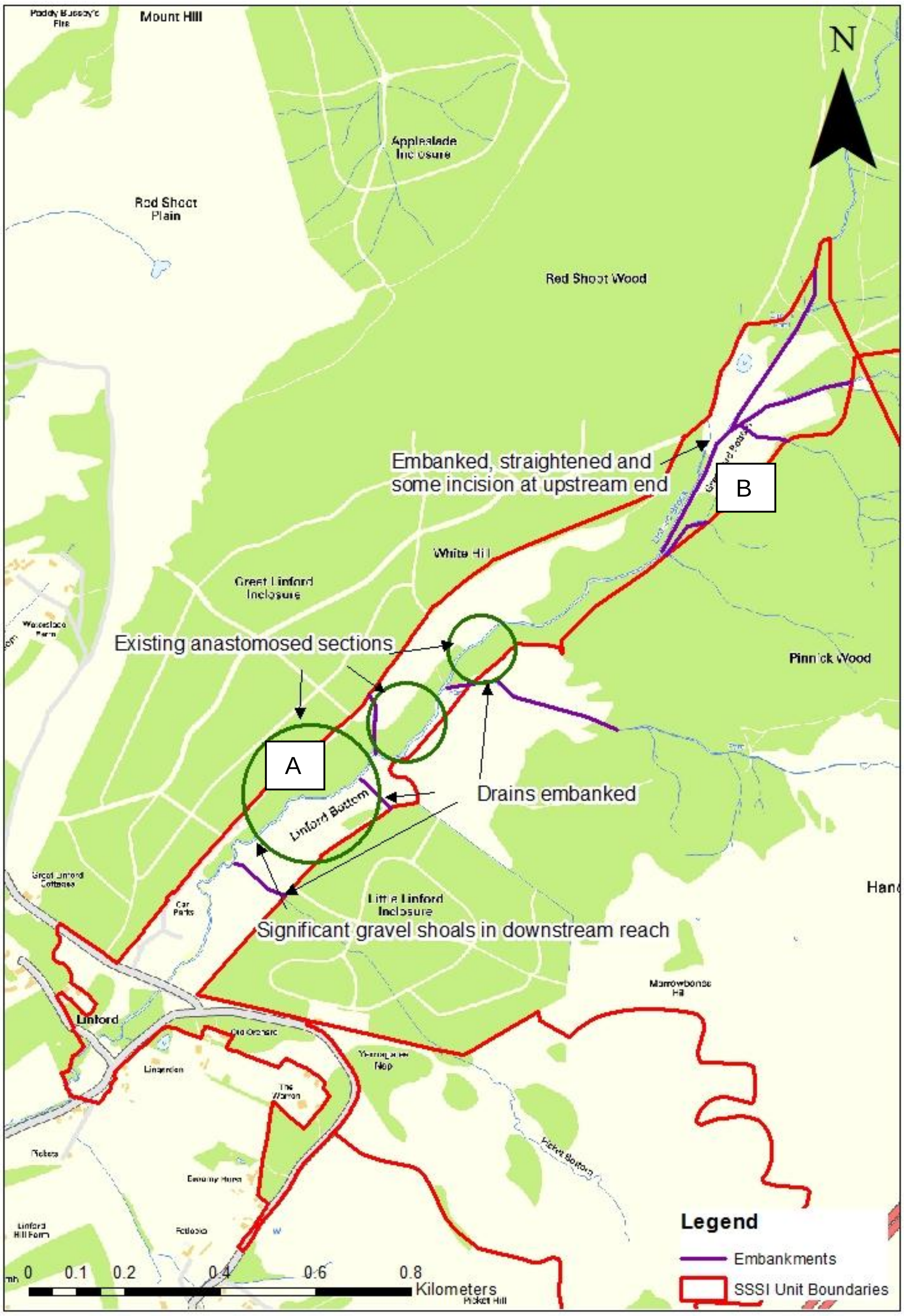
Linford Brook within SSSI Unit 88 is an active single thread channel with some short weakly anastomosed sections (Figure 1-2), that are moderately disconnected from the main channel. It has a strong upstream and local gravel supply, resulting in significant gravel shoal accumulations (Figure 1-3), particularly in the lower reaches linked to large scale local deposition and associated widening.

Figure 1-2: Anastomosed section characteristics

Figure 1-3: Gravel shoal development in some locations

The source of the stream is the SSSI Units 117 and 95 at Bratley Plain, and Milkham Inclosure. Figure 1-4 summarises the existing hydromorphology and pressure impacting unit 88.

Figure 1-4: Current hydromorphic conditions and pressures






Linford Brook has a moderate gradient throughout, with minor reductions where there are short anastomosed sections (Figure 1-4 - A). Straightening of the watercourse has occurred in the past, particularly in the upper reaches (Figure 1-4 - B), and this has had an effect on the functioning of the river in this section. The length of the watercourse will have been shortened (palaeo channels are evident from the LIDAR, particularly in the upper reach), which leads to steepening of the system and the dredging that will have occurred has over-deepened the channel. This leads to increased flood shear stress levels that can result in heightened erosion (Figure 1-5)

Figure 1-5: Bank erosion common in upper reaches

Where the channel banks are stronger (due to the presence of more resistant boulder clays rather than fluvio-glacial gravels or where riparian woody vegetation is dense enough to provide a coherent resistant root mat) and where there are embankments along the main channel, erosive energy has been concentrated into mild vertical incision into the bed leading to a further over-deepening, this is evident on site through tree root exposure and trees leaning inwards towards the channel (Figure 1-6). Where the banks are less resistant (due to tree clearance, presence of gravels etc.), which is particularly true in lower reaches of Linford Brook, lateral erosion will also have occurred. Often in rivers with moderate to high energy, lateral erosion and widening is also associated with bar deposition concentrating flows around gravel shoals and promoting further lateral activity (Figure 1-3).

Figure 1-6: Incision evidence in upper reaches - tree leaning

The initial impact of straightening would have been some incision along the upper sections of this unit (Figure 1-6) and channel widening across areas with erodible banks, which may have partially occurred in the lower reaches.

Ditching of the catchment will have impacted on the flood flow regime of the watercourse Ditching across the wider catchment will have impacted on the flood flow regime of the watercourse creating a more responsive system where flood peaks are concentrated and increased and water enters the main channel more efficiently and at concentrated points. The degree of artificial drain creation is shown in Appendix A and is impacting on the flow regime. This effectively creates a higher energy system more capable of erosion and sediment transport.

Significant shoals in the downstream sections of the unit are influencing channel hydraulics immediately upstream, reducing the water slope and promoting more deposition. This 'cut and fill' activity is evident along the stream with fill zones characterised by plane bed, shallow gravel reaches and more local gravel shoals and bars causing local lateral erosion. This pattern is often repeated over time as gravels are re-eroded and re-deposited.

Groundwater levels are likely to have been altered in the upper sections of this unit where there has been mild incision and embanking. Sections of the immediate floodplain have become drier than natural, resulting in heavy grazing. This is also true for areas local to straightened and embanked drains (Figure 1-7).

Figure 1-7: Straightened and embanked drain

Gravel supply (there are significant gravel sources within the river banks locally, particularly in the mid to lower reaches, Figure 1-8) is strong and this, combined with flow regime alterations through surrounding drains, as well as historic tree clearance, results in responsive channel conditions.

Figure 1-8: Local gravel sources within banks

The strong supply of gravels has resulted in significant gravel feature growth within the channel in the form of mid channel bars, lateral bars, transverse bars and point bars (Figure 1-3 and Figure 1-5). There is also a good riffle - pool - run sequence development in the mid to lower reaches, as well as some shorter plane bed sections.

Figure 1-9: Riffle - pool sequencing in mid to lower reaches

Natural woody debris features are also evident along the channel, within the wooded sections of the unit (Figure 1-10). These provide useful analogue features for incision management and water level raising to improve floodplain connectivity in the upper reaches of this unit.

Figure 1-10: Natural woody debris jams

There are numerous palaeo channels within this unit that are shown in Figure 1-12 and show where reconnection could be possible through some of the proposed restoration measures in Table 1-2. These have been identified from the audit and supplied LIDAR and a significant channel has been identified in the upper reach towards the east that would improve the hydromorphic condition through this section if it could be reconnected.

Grazing up to the river banks does occur in numerous locations, which results in reduced bank cohesion (leading to accelerated bank erosion) due to a lack of mature vegetation, and increased fine sediment inputs to the channel.

## 1.3 Probable channel development

The process of adjustment to the channel straightening, dredging, flow regime alteration and floodplain vegetation disruption in the upper reaches is continuing despite the historic nature of many of the changes. As such the river remains highly responsive in nature. In the upper reaches, incision could increase if left unmitigated, which would not only result in degradation locally but could also have impacts on unit 117 upstream.

In the mid to lower reaches, the hydromorphic condition is considered to be reasonable and in a recovering state with the river displaying typical characteristics of an active single thread channel. The nature and location of the gravel features within the unit are likely to change over the medium term. The condition of the channel could be further improved with better connection to the floodplain that would result in further anastomosed channel network development and a locally wetter improved riparian margin

The straightened and embanked drains also require works to restore a more natural flood regime.

Grazing will continue to maintain an active single thread section of channel through a lack of mature vegetation growth in the riparian zone in some areas.

## 1.4 Current ecological conditions

Broadleaved woodland occurs adjacent to the watercourse, which is a mixture of riparian and pasture woodland. The riparian woodland occurs mostly along the downstream section of the watercourse, with some areas immediately adjacent to the watercourse in the central section of the unit. It consists predominantly of Grey Willow *Salix cinerea* and Downy Birch *Betula pubescens* and can be classified as W1 woodland; this is typical of floodplain woodlands on sluggish streams. Larger stands of pasture woodland also occur, particularly on the north side of the watercourse and these are dominated by Oak *Quercus robur* with a spartse understorey dominated by leaf letter and patches of Bracken and comes closest to W16.

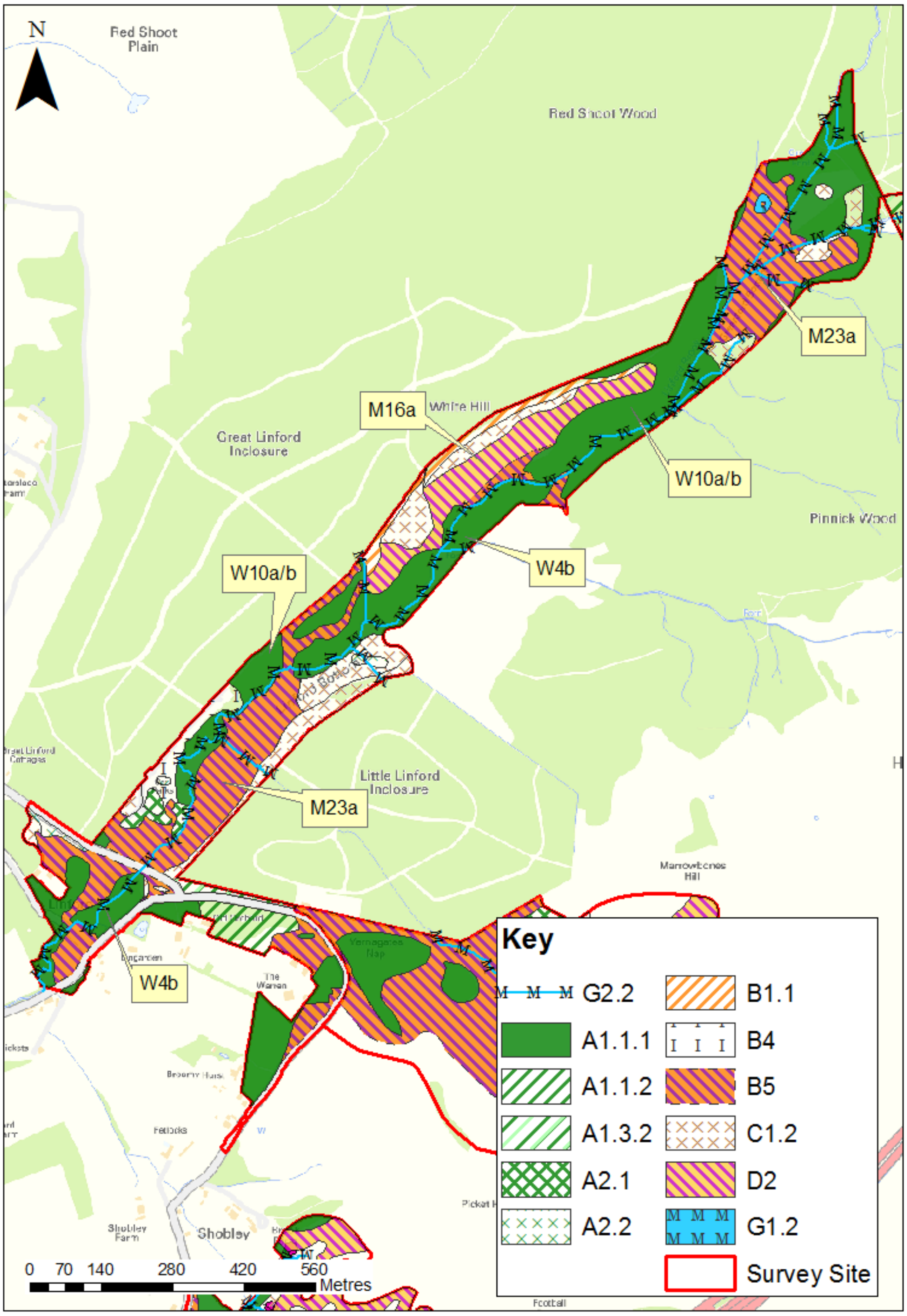
Large areas of wet grassland (lawns) are also present but in places these are becoming invaded with scrub, Gorse *Ulex europaeus* and Bracken *Pteridium aquilinum*. These are closely grazed and have been dry for some time as there are few remaining *Molinia* tussocks. These can be classified as M23a rush pastures.

Within the central section of the unit, to the north of the watercourse there is an area of wet heath with abundant patches of Cross-leaved Heath *Erica tetralix* and also frequent Bracken.

Some small patches of Rhododendron *Rhododendron ponticum* were also present on the banks of the watercourse.

Figure 1-11 shows the Phase 1 Habitat Map for Unit 88.

Figure 1-11: Phase 1 Habitat Map






## 1.5 Restoration plan proposals

A summary of the current pressures, unmitigated impacts and restoration proposals is given in Table 1-2 and shown in Figure 1-12.

The key hydromorphological and ecological gains associated to the proposed restoration measures are:

- Palaeo channel reconnection, alongside embankment removal and incision management in the upper reach creating improved morphological features;
- Improved anastomosed channel network development will improve hydromorphological diversity;

- Better floodplain connection through water level raising and artificial drain restoration;
- Opportunities to increase the area and improve the quality of bog woodland, wet grassland and wet heath habitats within the floodplain

Table 1-2: SSSI Unit 88 proposed restoration measures

| Pressure | Impact | Restoration proposal | Hydromorphic improvement | Ecological improvement | Constraints / issues |
|---|---|---|---|---|---|
| Straightening / dredging - particularly in the upper reaches | Long term river response, cut and fill activity.<br><br>Enhanced in-channel energy levels.<br><br>Disconnected sub / palaeo channels.<br><br>Loss of in-channel features. | Palaeo channel reconnection.<br><br>Infill.<br><br>Restore in-channel morphology.<br><br>Restore connectivity.<br><br>Incision management - debris jams, morphological restoration. | Reinstate some channel length lost through straightening in the upper reaches - helping to reduce incision.<br><br>Debris jams naturally occur along the reach, use local materials.<br><br>Morphological enhancement to raise bed and water levels will help improve floodplain connectivity.<br><br>Encourages anastomosing channel development.<br><br>Reduces fine sediment inputs.<br><br>Slows gravel movement.<br><br>Stabilises in-channel features. | Improve diversity of in-channel and floodplain habitats.<br><br>Increase availability of ecological niches.<br><br>Promote the recolonisation of *Molinia* to re-create M25a mire.<br><br>Opportunities to increase the area and improve the quality of riparian woodland, wet grassland and wet heath habitats within the floodplain<br><br>Promote seral communities on revegetating gravel bars. | Debris jams may form a barrier to fish, however, it is unlikely that a fish pass may be required.<br><br>Loss of grazing land both spatially and temporally<br><br>Cultural objections. |
| Embanking - upper reaches and drains | Enhanced in-channel energy levels.<br><br>Disconnected sub-channels. | Embankment removal - main channel and drains | Reconnect the floodplain, reducing incision rates and improving in-channel hydromorphic conditions.<br><br>Drain embankment material could be used to infill drains.<br><br>Slows gravel movement.<br><br>Stabilises in-channel | Reconnect stream with floodplain and promote the formation of Soakways (M29).<br><br>Increase flooding frequency and nutrient input to system naturally.<br><br>Stabilised in-channel features provide additional habitat and promote further | Drains may also require infilling to restore natural flow regime and reduce incision.<br><br>Loss of grazing and inaccessibility of areas at time of high water.<br><br>Light levels reaching watercourse |

| Pressure | Impact | Restoration proposal | Hydromorphic improvement | Ecological improvement | Constraints / issues |
|---|---|---|---|---|---|
| | | | features. | stabilisation. | |
| Artificial drainage | High flows impacted.<br><br>Water table lowered locally. | Drain infilling | Restore a natural flow regime, reducing incision in the drain and channel network.<br><br>Reduces flood peaks.<br><br>Reduces fine sediment inputs.<br><br>Slows gravel movement.<br><br>Stabilises in-channel features. | Improve diversity of in-channel habitats and reconnection of floodplain.<br><br>Raise water table on floodplain and promote regrowth of *Molinia* mire (M25a) habitat. | May require import of material. |
| Poorly connected anastomosed sections | Channel network in the floodplain only activated at higher flows | Water level raising through debris jams, morphological feature enhancement | Improved anastomosed sections.<br><br>Improved floodplain connectivity.<br><br>Channel stabilisation in short sections. | Improve diversity of in-channel and floodplain habitats. Opportunities to increase the area and improve the quality of riparian woodland, wet grassland and wet heath habitats within the floodplain | Debris jams may form a barrier to fish, however, it is unlikely a fish pass may be required as these obstructions are ephemeral in nature |
| Woody invasive species | Alters floodplain species assemblage.<br><br>Impacts bank stability. | Non-native species control (Rhododendron and conifer species).<br><br>Exterminate and allow natural regeneration / plant alder & willow. | Removal of conifer plantations would improve low flow hydrology and reinstate a natural drainage pattern.<br><br>Creates riparian hydromorphic diversity. | Permit greater light amounts to reach ground layer and promote release.<br><br>Restoration of floodplain wetland habitats. | Large-scale removal of conifer species is unlikely to be feasible or economically viable<br><br>Cultural objections. |
| Riparian vegetation removal | Loss of bank stability.<br><br>Loss of shading.<br><br>Loss of organic inputs to the watercourse. | Reduced tree clearance at bank edge.<br><br>Selected felling into watercourse and promoting regrowth<br><br>Ring-barking of selected trees. | Will help to stabilise banks in the active sections in the mid to lower reaches and alongside bed restoration to minimise incision, could improve floodplain connectivity<br><br>Creates riparian | Opportunities to improve and expand bog woodland habitat in floodplain<br><br>Increase light levels reaching the ground and promoting release. Increased amounts of standing dead wood and | Tree clearance is a necessity in some locations.<br><br>Cultural objections |

| Pressure | Impact | Restoration proposal | Hydromorphic improvement | Ecological improvement | Constraints / issues |
|---|---|---|---|---|---|
| | | Replant or allow to naturalise through reducing grazing pressure. | hydromorphic diversity.<br><br>Acts as fine sediment trap.<br><br>Allows woody debris accumulation. | CWD in and alongside the watercourse.<br><br>Increased saproxilic flora and associated food chain gains in biodiversity. | |
| Riparian grazing | Fine sediment production.<br><br>Disruption to woody species recruitment.<br><br>Promotion of active single thread channel conditions | Exclude livestock | Encourages riparian hydromorphic diversity | Increased floristic diversity of ground flora on floodplain.<br><br>Restoration of wetland habitats, especially M25a. | Some grazing is likely to be maintained<br><br>Culturally unacceptable |

Figure 1-12: Proposed restoration measures for SSSI Unit 88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## 1.6 Design considerations

The channel is unlikely to completely stabilise as a result of re-routing the watercourse back through a palaeo channel that was once occupied, probably at a time when channel and catchment processes and pressures would have been very different from today. However, retaining the dynamism of the channel should be an objective of the restoration plan and increasing the channel length will alleviate a portion of the erosive pressures in the upper reaches. Focus in the mid to lower reaches should be on improving floodplain connectivity and encouraging further anastomosed channel network development.

Palaeo-channel entrance and exit elevations must be carefully considered to avoid instigating uncontrolled instability.

The major straightened / modified drainage channels are identified in Figure 1-12. Other minor modifications could be considered for infilling and Appendix A should be used for reference.

Works within this unit should be prioritised or aligned with works undertaken in units 117 upstream and 91 downstream. The linkage between the units is important and issues identified within units 117 and 91 are likely to be impacted / mitigated by works undertaken in this unit.

There are possible impacts on flood risk as a result of some of the restoration proposals for this unit. Therefore, a Flood Risk Assessment may be required to determine whether there are any impacts that could affect properties at Linford and surrounding areas downstream.

## 1.7 Restored channel and monitoring requirements

It is anticipated that the proposed restoration works maintain a dynamic, sinuous channel with some anastomosed sections and improved floodplain connectivity, with frequent overbank flooding and a heightened potential for local channel switching in response to natural debris blocking. This pattern of development is difficult to document accurately due to the complex nature of the river network and the difficult surveying conditions. As such a qualitative monitoring approach is recommended with automated time lapse photography employed at key restoration points to record daily images of flow types, morphology and vegetation character. This could be undertaken alongside two-yearly reconnaissance audits to determine hydromorphological change over the entire reach, which fixed point photography will not cover. The daily photographic records should be analysed to estimate and record the parameters detailed in Table 1-3.

Table 1-3: Monitoring parameters, frequency and suggested approaches for the Unit 88.

<table>
<tr><th>Parameter</th><th>Approach</th><th>Frequency</th><th>Approximate cost</th></tr>
<tr><td>Morphologic unit change</td><td>Time lapse camera / audit</td><td>Daily (Annual statistical summary)</td><td rowspan="4">Capital 5 x £200<br>Half yearly downloading £200<br>Annual summary £300<br>Two - yearly reconnaissance audit £500</td></tr>
<tr><td>Flow change</td><td>Time lapse camera / audit</td><td>Daily (Annual statistical summary)</td></tr>
<tr><td>Sedimentology</td><td>Time lapse camera / audit</td><td>Daily (Annual statistical summary)</td></tr>
<tr><td rowspan="3">Vegetation change</td><td>Fixed point camera survey</td><td>Biennially</td></tr>
<tr><td>Fixed point quadrat survey</td><td rowspan="2">Biennially</td><td rowspan="2">Survey £350<br>Analysis £500</td></tr>
<tr><td>Fixed point aquatic macrophyte survey</td></tr>
<tr><td colspan="4">NB. Costs assume downloading and site visits as part of wider field campaign.</td></tr>
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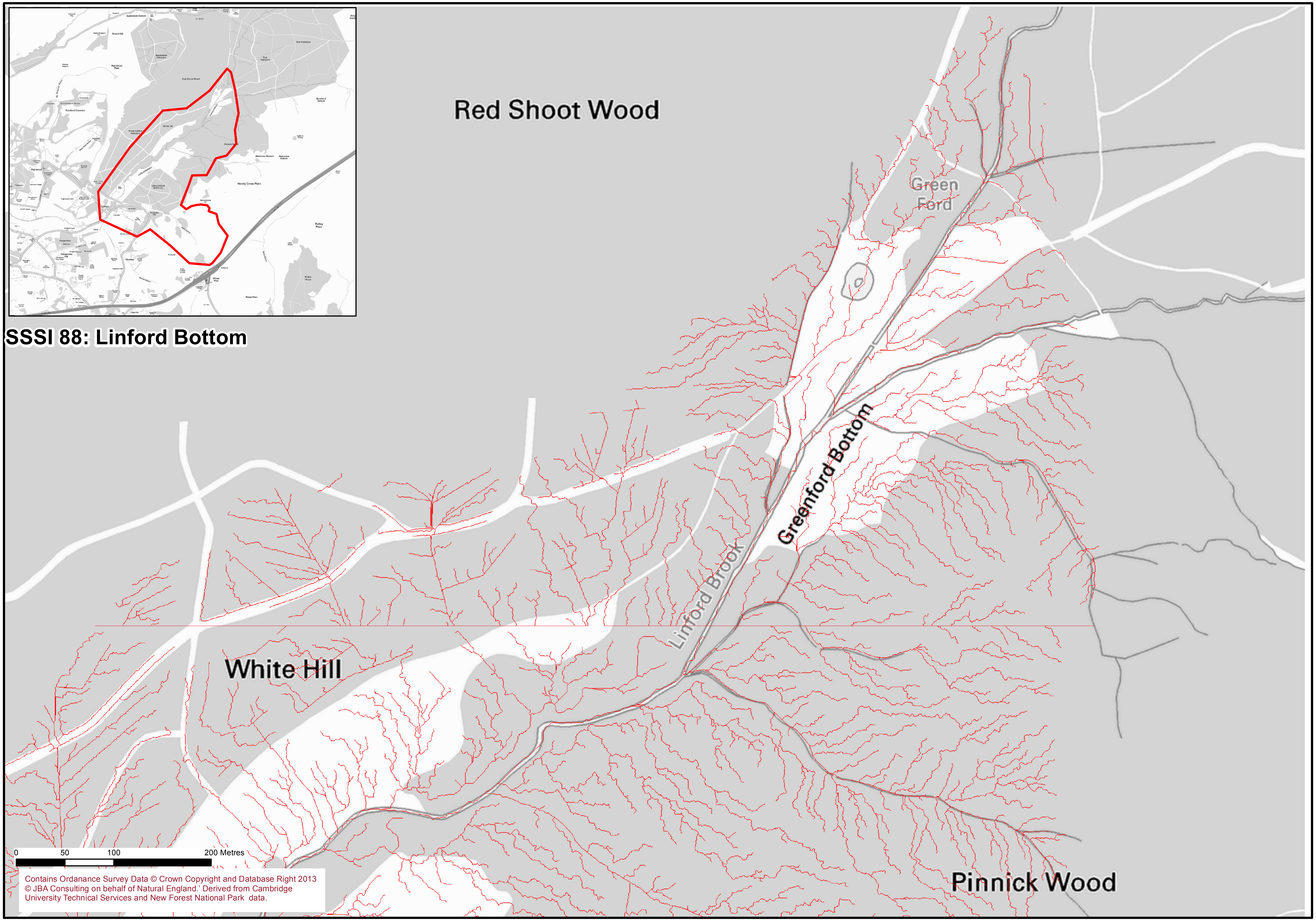
## Appendix A - Artificial flow lines and drain lines SSSI Unit 88


SSSI 88: Linford Bottom
Red Shoot Wood
Green Ford
Greenford Bottom
Linford Brook
White Hill
Pinnick Wood
0 50 100 200 Metres
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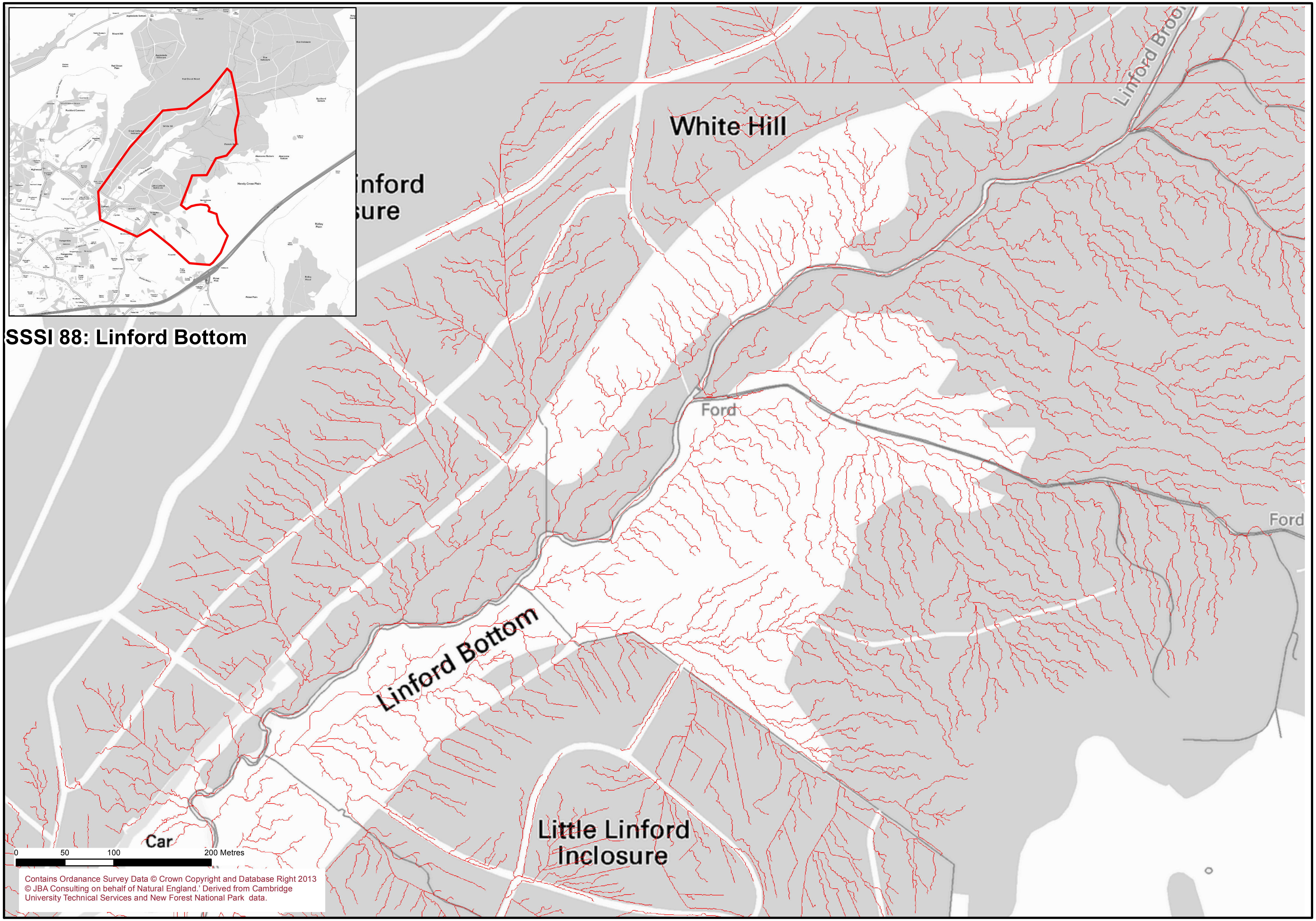
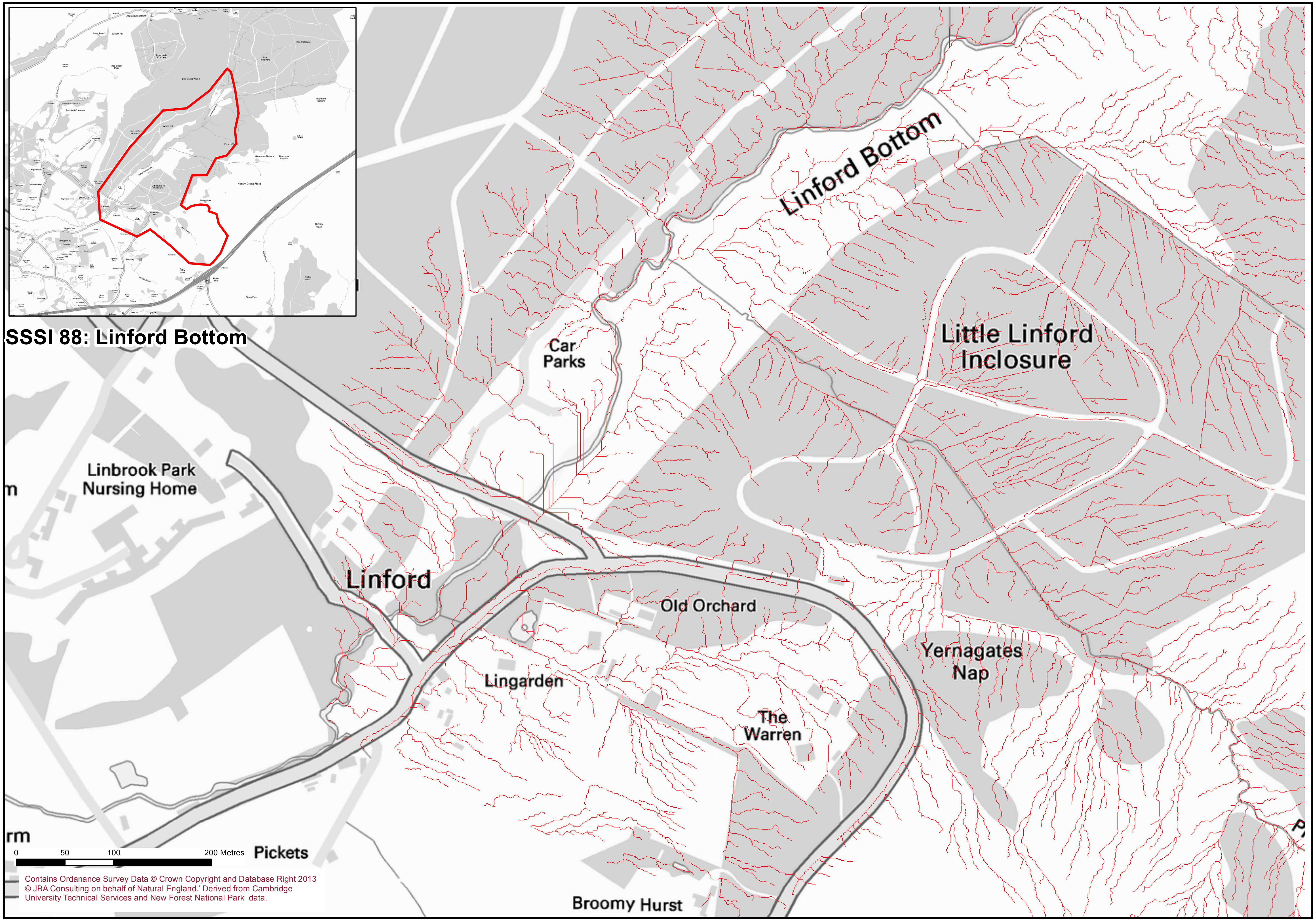
University Technical Services and New Forest National Park data.

# SSSI 88: Linford Bottom




SSSI 88: Linford Bottom
Linford Bottom
Car Parks
Little Linford Inclosure
Linbrook Park Nursing Home
Linford
Old Orchard
Yernagates Nap
Lingarden
The Warren
Pickets
Broomy Hurst
0
50
100
200 Metres
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