Physical and biological monitoring of STREAM restoration projects

Year One Report

Natural England

February 2007

Final Report

LIFE05 UK/NAT/000143
9S0459

STREAM

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HASKONING UK LTD.
ENVIRONMENT

Burns House
Harlands Road
Haywards Heath, West Sussex RH16 1PG
United Kingdom
+44 (0)1444 458551 Telephone
01444440665 Fax
info@haywards-heath.royalhaskoning.com E-mail
www.royalhaskoning.com Internet

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Drafted by	Joanna Eyquem	
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CONTENTS

(*All appendices are contained in a ringbinder that accompanies this report and will be updated on an annual basis)

1 INTRODUCTION

1.1 The STREAM Restoration Project

Demonstrating Strategic Restoration and Management (STREAM) is a LIFE nature funded project being undertaken by Natural England (English Nature) to improve river habitat conditions along a number of reaches of the River Avon Special Area of Conservation identified in **Table 1.1** and **Figure 1.1**.

Table 1.1 Location of river restoration sites within the Avon catchment

Site name	Watercourse	Upstream limit	Downstream limit
1.1 Upper Woodford	River Avon	SU 13183755	SU 12603723
1.2 Fovant	River Nadder	SU 00213059	SU 00663072
1.3 Seven hatches	River Wylye	SU 09243304	SU 09833178
1.4 Amesbury	River Avon	SU 15834257	SU 15624195
1.5 Hale	River Avon	SU 17401889	SU 16351791
1.6 Blashford	Dockens Water	SU 15410828	SU15300826

Further details about the project and outline design of the restoration works to be undertaken are contained within the original LIFE bid document (English Nature, 2005).

1.2 Physical and Biological Monitoring

As part of the STREAM project, Royal Haskoning has been commissioned by Natural England to undertake physical and biological monitoring at each of the six restoration sites.

Monitoring will involve one pre-restoration and one post-restoration survey at each site. These surveys will be used to document the restoration works and to identify the possible influence of the works on ecology within the reach. Reach-scale mapping and repeat photography techniques will be used to monitor change at all restoration sites. It is not possible to undertake detailed survey at all sites due to resource constraints and practical limitations. Therefore two of the sites will also be subject to more detailed survey and the use of control sites.

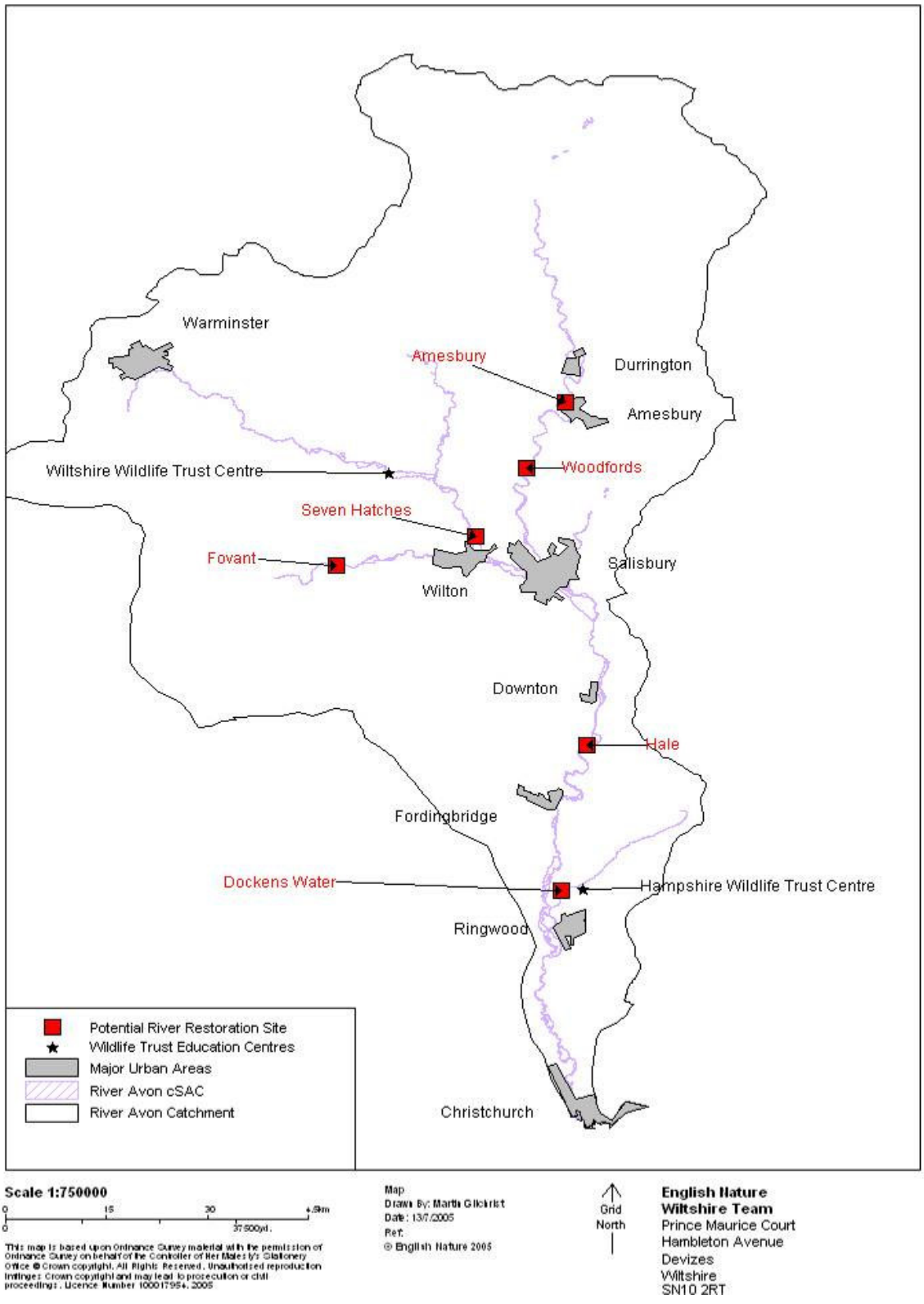
1.3 Reporting format

The findings of the monitoring project will be reported at the end of each of the four years of the project. This document reports on the findings of the first year's baseline monitoring surveys undertaken in 2006 at the following sites:

Detailed survey
- Upper Woodford Control (UWC) and Restoration (UWR) sites
- Seven Hatches Control (SHC) and Restoration (SHR) sites

Rapid assessment
- Fovant Restoration Site (FOR)
- Amesbury Restoration Site (AMR)

Figure 1.1 Location of STREAM restoration sites within the Avon Catchment



The purpose of this report is to present the data that has been collected to date and summarise any initial findings in relation to the physical and biological characteristics of the sites surveyed.

The primary data is contained in the accompanying ringbinder of appendices. This ringbinder will be updated following subsequent annual reports in order to collate all of the data gathered over the four year period in one place.

2 METHOD

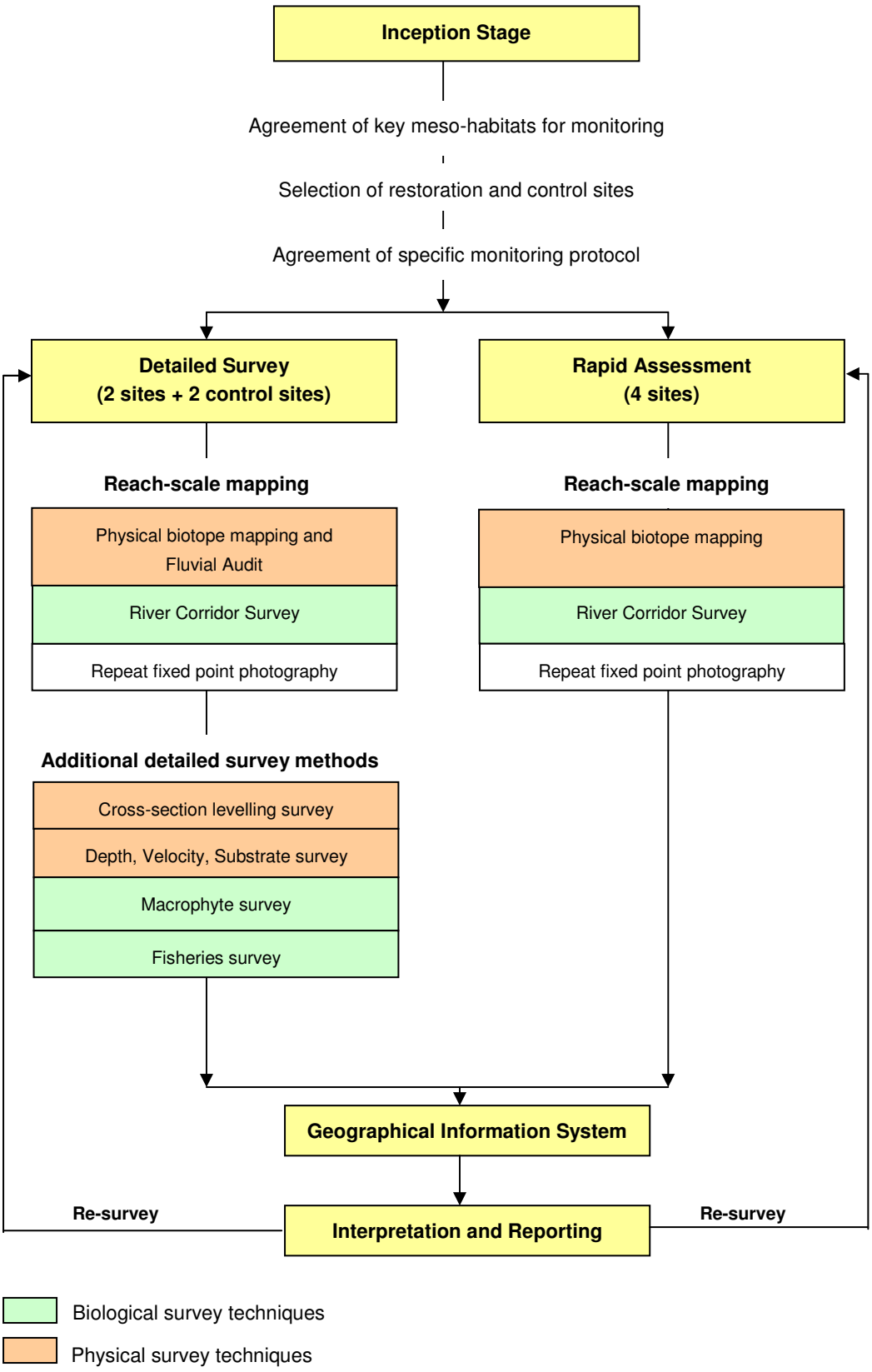
2.1 Monitoring Protocol

The methods used in gathering the physical and biological survey data presented in this report are based on those agreed with Natural England in developing the STREAM Monitoring Project – Monitoring Protocol (Royal Haskoning, 2006). The monitoring protocol describes how the monitoring sites were selected and the monitoring framework (**Figure 2.1**) together with the rationale underlying the project and should be read in conjunction with this report.

The following statements define the purpose and limitations of the monitoring framework.

- The pre-restoration survey will establish a record of biological and physical conditions at the site prior to restoration.
- The post-restoration survey will record modifications to physical conditions after restoration.
- The surveys will both provide snapshots pre- and post-restoration. It is important to recognise that there is a limitation to the comparisons that can be made over this short duration and it will not be possible to draw any conclusions regarding changes in conditions at a site pre / post-restoration.
- The relationship between physical and biological conditions will be analysed at each site. Comparisons will be made concerning the relationships identified at each site at the time of survey, taking into account other factors and processes that may influence relationships.
- The limitations of the control sites will prevent direct comparison of the restoration reaches with the control sites. The purpose of using the control site is to compare the relationship between physical and biological conditions at recorded at both sites on a given day rather than to compare the magnitude of change of either physical or biological parameters between sites. Comparisons will therefore be made between pre-restoration and post-restoration surveys at each individual site. Inference may be drawn about changes in each parameter and in the relationship between physical and biological character.
- This monitoring framework will establish a documented baseline in order that repeat surveys of both physical and biological conditions can be made over longer time periods.

Figure 2.1 **Monitoring framework for the STREAM Monitoring Project**



2.2 Realisation of the Monitoring Protocol

2.2.1 Reach-scale mapping

Reach-scale mapping of all sites was undertaking according to the monitoring protocol using Fluvial Audit, Physical Biotope Mapping, River Corridor Survey and repeat photography. Fluvial Audit sheets, Physical Biotope maps and River Corridor Survey maps have been prepared for each site and are presented in **Appendix A**. Definitions of the physical biotopes that were used during Physical Biotope Mapping are provided in Table 2.1. These definitions are consistent with those used during River Habitat Survey (RHS).

Table 2.1 Physical biotope definitions

Physical Biotope	Definition
Rapid	Boulder/cobble substrate with stepped profile. Associated with 'white water' from broken standing waves
Riffle	Shallow, fast flowing, discrete section of up to 5 channel widths in length. Unconsolidated gravel substrate with 'bubbling' unbroken standing waves.
Run	Shallow, fast flowing section, similar in character to a riffle but not a discrete feature.
Boil	Associated with upwelling flow, typically found on the outside of tight meander bends, behind structures, d/s of waterfalls
Glide	Section of smooth or rippled flow, deeper flow than a run.
Pool	Sections of deeper flow of up to 3 channel widths in length that are sustained by scour. Typically located on the outside of meander bends, downstream from bedrock outcrops (plunge pools) and weirs. Does not include impounded sections.
Ponded reach	Sections of no perceptible flow where water is impounded upstream of natural bedrock controls and weirs.
Marginal deadwater	Margins of the main channel where there is no perceptible flow.

For definitions of other terms used in the Fluvial Audit and River Corridor Survey please refer to the relevant reference sheets within **Appendix A**.

Photographic survey records are contained within **Appendix B.** In some locations it was unfeasible to use the tripod to take the photographs associated with the macrophyte transects due to the embanked nature of the channel and poor visibility through riparian and emergent vegetation. In these cases, the height from which the photograph was taken was recorded using a tape measure.

2.2.2 Macrophyte survey

Macrophyte survey was undertaken according to the monitoring protocol using the rapid assessment method identified in Monitoring *Ranunculion fluitantis* and *Calitricho-Batrachion* Vegetation Communities (**Life in Rivers, 2003**). The estimated coverage of macrophyte species within the transects surveyed is presented in **Appendix C**.

Reporting on the findings of this survey focuses on the coverage and absence of the species found during the survey. Key species are defined as species of water-crowfoot (*Ranunculus spp.*) and starwort (*Callitriche spp.*) present in the vegetation communities, for which the River Avon is designated as a Special Area of Conservation (SAC). Other key species are those identified to be of regional and local importance. Hemlock water

dropwort (*Oenanthe crocata*) is defined within the River Avon SAC Conservation Strategy as of local importance (**English Nature, 2003**), while common meadow rue (*Thalictrum flavum*) is a regionally scarce species (**Pilkington, 2006 pers. comm.)**

The only negative indicator that was identified during the survey was fennel pondweed (*Potamogeton pectinatus*) and the only invasive species recorded was Himalayan Balsam (*Impatiens glandulifera*). The absence of other negative or invasive species known to be present in the Avon catchment, such as Canadian pondweed and water milfoil is therefore not commented on for each reach.

2.2.3 Cross-sectional levelling

Cross-sectional levelling survey was undertaken at eight cross-sections at each site according to the monitoring protocol, except at the Upper Woodford Restoration Site (UWR) where an additional ninth cross-section was surveyed. Cross-sectional levelling data is contained within **Appendix D**.

2.2.4 Depth, Velocity and Substrate (DVS) survey

Velocity readings were taken alongside the cross-sectional levelling survey of each cross-section. Velocity was measured at regular 2m (sites UWC and UWR) or 1m (sites SHC and SHR) intervals across the channel (see **Appendix D**). However, since accurate measurements had already been taken to determine the cross-sectional profile, measurements of depth were not taken at the same time. Such measurements of depth would have been less accurate than those already taken of bed elevation and water depth during the cross-sectional levelling survey. The mean velocity was therefore calculated using the regularly spaced velocity readings and the cross-sectional area of flow calculated using the levelling survey data.

The calculated mean velocity was multiplied by the cross-sectional area of flow to calculate discharge. However, due to the extremely low velocities within each reach, the calculation of discharge is highly sensitive to small variations in velocity and the calculated values showed unexpected variation throughout the reach. These variations are likely to be due, in part, to error in measuring low velocities in the field and are therefore not presented within the results.

Measurement of bed substrate was undertaken at five locations along the cross-section according to the monitoring protocol, using the definitions provided in **Table 2.2**. The bed substrate data collected during survey is also presented in **Appendix D**.

Table 2.2 Bed substrate definitions

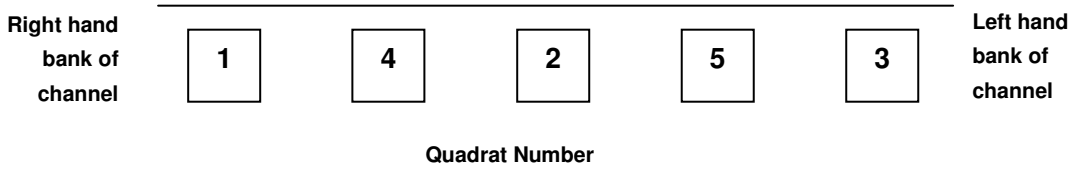
Bed Substrate	Defintion
Clay	Particle size < 0.002 mm
Silt	Particle size 0.002 – 0.063 mm
Sand	Particle size 0.063 – 2 mm
Gravel	Particle size 2 – 16mm
Pebble	Particle size 16 – 64 mm
Cobble	Particle size 64 – 256mm
Artificial	Non-natural bed material (e.g. concrete)

The term “bankfull” is referred to, in accordance with the River Habitat Survey (RHS) methodology, as the width, depth or area of the cross-sectional profile corresponding with the maximum flows that are contained within the channel itself, prior to spilling out onto the floodplain. The “cross-sectional area of flow” refers to the cross-sectional area covered by water at the time of survey.

2.2.5 Fisheries survey

The fisheries survey was undertaken based on the methods set out within the monitoring protocol. The quadrat survey of lamprey was undertaken at each site using the quadrat layout indicated in **Figure 2.2**.

Figure 2.2 Numbering scheme for quadrats used during the lamprey survey



Practical limitations encountered in the field made it necessary to make some alterations to the fisheries survey method on site. These alterations were standardised for all of the sites surveyed to maintain consistency. Some of the limitations encountered may also affect the quality of the data that could be collected. The key issues encountered are listed below and should be considered in using the data collected during the fisheries survey.

- Fisheries survey was conducted within all of the meso-habitats proposed in the monitoring protocol. In some cases, the location of the survey area within meso-habitats was altered, for example to take into account areas where the water was too deep to enable survey. The locations that were surveyed are indicated within this annual report.

- The first run for each site was dominated by the capture of larger fish, notably trout, grayling and eels (>100g). They were captured and housed in oxygenated tanks for the remaining duration of the survey to avoid capture on subsequent runs.

- The electric field has a greater effect the larger the fish. During the first survey run, whilst large fish remained in the river, a current of 3 amps was used. Once the large fish had been removed the current was turned up to enable the capture of smaller fish. This was undertaken consistently at all sites and considered necessary as many smaller fish were otherwise not pulled in by the lower current due to the weak electric field.

- Due to time constraints once two runs had been carried out and no salmon had been caught, a third run was not undertaken. Analysis of data relating to bullhead has therefore only been based on data from the first and second runs.

- The large size of the river constrained the capture of bullheads and optimum habitat was preferentially surveyed over sub-optimum habitat areas (within the same meso-habitat).

- Rain splash and dense cloud cover made spotting small fish (particularly 0+ bullhead and lamprey ammocoetes) extremely difficult. This problem was exacerbated in deeper water.

- Insufficient salmon were caught to enable depletion analysis. The number of bullhead caught at the majority of sites was also insufficient for depletion analysis. Presentation of fisheries survey data has therefore focused on the minimum density of fish observed and the number of fish caught, including Annex II and other fish species.

3 DETAILED SURVEY RESULTS

3.1 Upper Woodford Control Site (UWC)

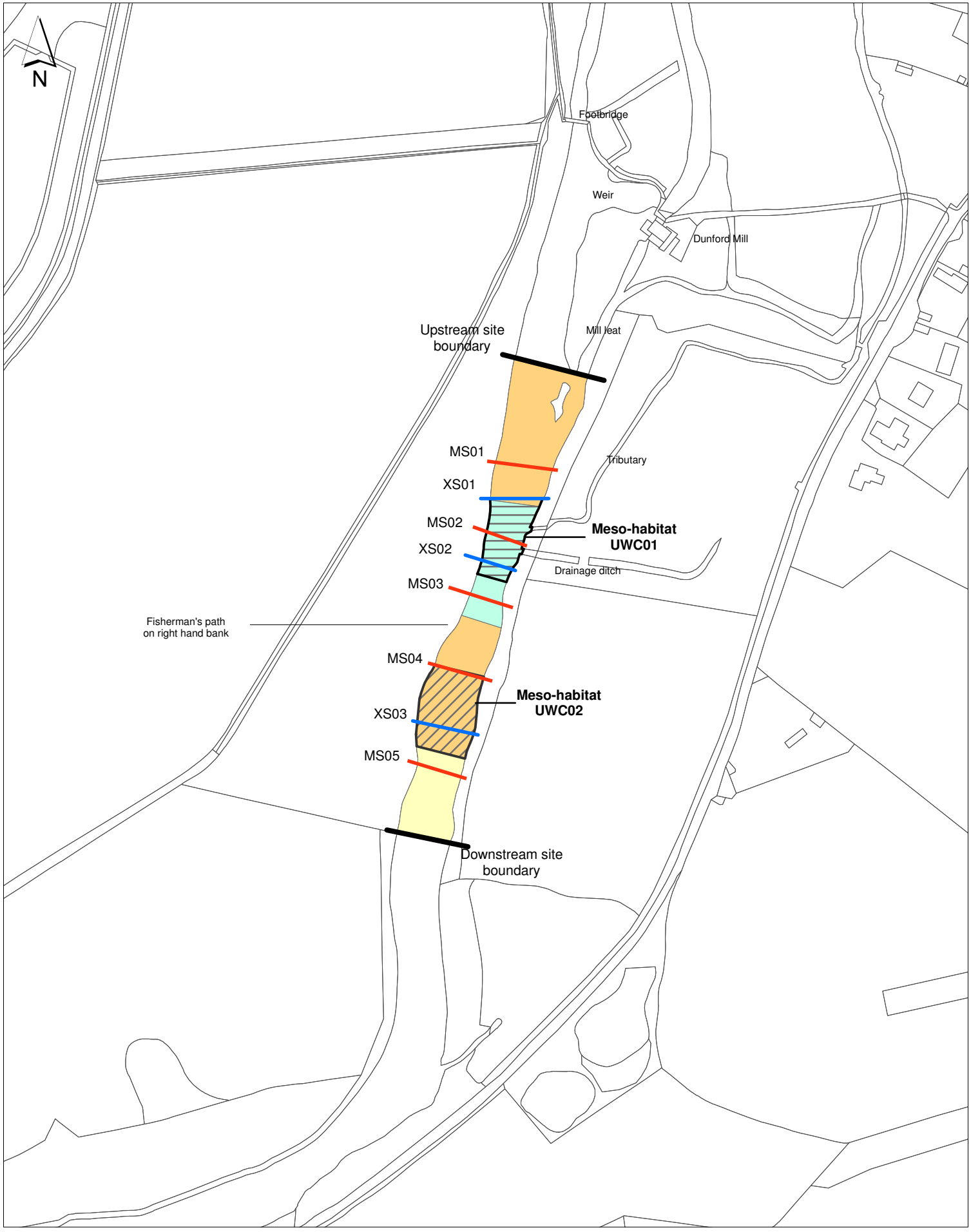
Upstream limit: 413238 137851
Downstream limit: 413181 137563
Length of site: 250m

Location:
The site is located downstream of Durnford Mill where there is a sluice and a large weir, which create rapid flow conditions immediately upstream of the study site (**Map 3.1**). The upstream boundary of the site is located where the mill leat from the mill re-enters the main channel. The downstream boundary of the site is located parallel with boundary fencing on the right hand bank.

Typical photographs:

Photo UWC01c:
Run biotope towards the upstream end of site UWC, looking downstream.

Photo UWC01g:
Glide biotope looking upstream from the downstream boundary of site UWC.



Legend

- Run
- Glide (rippled)
- Glide (laminar)

Cross-section location

- Macrophyte transects (MS)
- Additional corss-sections (XS)

Fisheries meso-habitat

- UWC01
- UWC02

Title: Upper Woodford Control Site (UWC)
Physical biotopes and survey references

Project: Avon STREAM Monitoring Project

Client: Natural England

Date: 27/11/2006

Scale: 1:2,500

Map 3.1

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3.1.1 Physical Characteristics

Physical biotopes
Two runs and two glides were recorded within the site during the Physical Biotype Mapping survey. These biotopes occur alternately, as illustrated in **Map 3.1**, and provide varied flow conditions within the site.

Sediment regime
The Fluvial Audit recorded little evidence of channel adjustment through erosion or deposition (see **Appendix A**), often found to be characteristic of a typical chalk stream. No point or diffuse sediment sourcing and no defined sediment sinks (e.g. channel deposits) were observed within the main channel. A drain enters the channel along the left hand bank at cross-section MS02 and is likely to act as a source of fine sediment.

Physical channel form
Levelling survey was conducted at eight cross-sections, the locations of which are illustrated in **Map 3.1**. Cross-sections with the pre-fix "MS" are those that were also subject to macrophyte assessment (see 3.1.2). Cross-sections with the pre-fix "XS" are cross-sections located to ensure measurements were distributed throughout the site.

Graphical presentation of the cross-sections is provided in **Appendix D** together with the original data. **Table 3.1** provides summary data for each of the cross-sections surveyed.

Table 3.1 Cross-sectional summary data

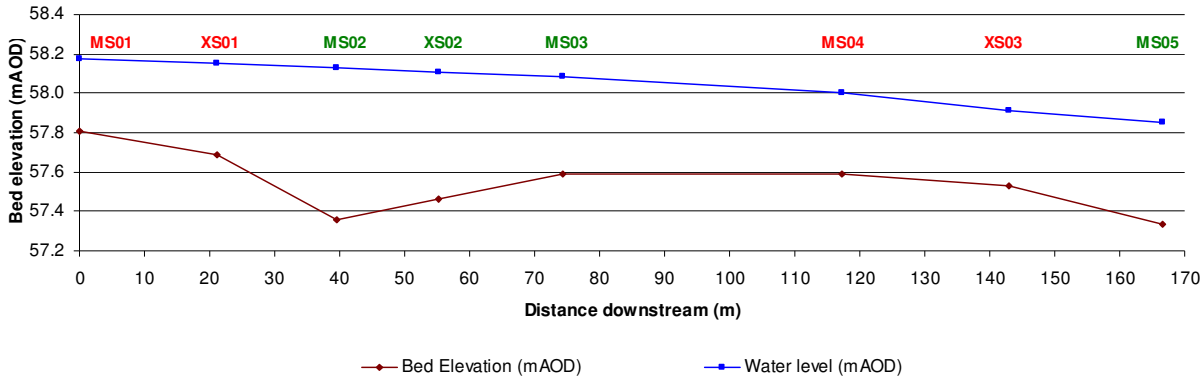
Transect	Physical biotope	Bankfull width (m)	Bankfull depth (m)	Width:depth ratio	Water width (m)	Water depth (m)
MS01	Run	38.56	0.70	55.3	33.28	0.36
XS01	Run	37.67	0.74	50.7	24.51	0.46
MS02	Glide	26.88	1.00	26.9	20.83	0.77
XS02	Glide	24.90	0.71	34.9	19.99	0.64
MS03	Glide	32.68	0.90	36.4	24.79	0.49
MS04	Run	35.10	0.65	53.8	30.44	0.41
XS03	Run	38.53	0.50	77.5	26.35	0.38
MS05	Glide	28.43	0.82	34.8	19.20	0.52
Mean		**33.91**	**0.75**	**47.8**	**26.83**	**0.50**

The channel is widest upstream of cross-section MS01, where there are two existing in-channel islands and the mill leat enters the channel (**Map 3.1**). Of the cross-sections surveyed, those situated within sections of run physical biotope are generally wider and shallower at bankfull, and consequently have a higher width:depth ratio than those situated within sections of glide physical biotope (**Table 3.1**). Water depth is lower over a greater width of channel within the run sections of the site.

Downstream of cross-section MS01, the channel has been narrowed through the use of willow spilling on both banks (see **Appendix A**).

The long profile of the channel, derived using the deepest points at each of the cross-sections, is presented in **Figure 3.1**.

Figure 3.1 Long profile derived from cross-sectional data from MS01 to MS05



Over a distance of 167m (between cross-section MS01 and MS05), there is a fall in bed elevation of 0.48m, corresponding to a gradient of 0.003. The long profile illustrates that the channel is typically deeper through the glide sections of the channel in comparison with the run sections.

Boundary conditions

The channel banks are graded and are extensively obscured from view by vegetation on both banks. Where visible the banks were observed to be composed of sand/silt material.

Bed substrate samples taken from the channel centre, both channel margins and intervening points (see **Table 3.2**) indicate that the dominant substrate is gravel / pebble material (2-64mm in diameter).

Table 3.2 Bed substrate and flow velocities sampled at surveyed cross-sections*

Transect	Physical biotope	Right channel margin	Right of channel centre	Channel centre	Left of channel centre	Left channel margin
MS01	Run	Silt	Gravel / **Pebble**	**Gravel** / Pebble	Gravel / **Pebble**	**Gravel** / Pebble
		0.00	0.07	0.00	0.03	0.01
XS01	Run	Gravel / **Pebble**	Gravel / **Pebble**	Gravel / **Pebble**	**Gravel** / Pebble	Silt
		0.50	0.01	0.01	0.22	0.00
MS02	Glide	Gravel / **Pebble**	Gravel / **Pebble**	Gravel / **Pebble**	Gravel / **Pebble**	Sand
		0.22	0.03	0.01	0.07	0.00
XS02	Glide	**Gravel** / Pebble	**Gravel** / Pebble	**Gravel** / Pebble	**Gravel** / Pebble	Sand
		0.01	0.32	0.02	0.04	0.00
MS03	Glide	Gravel / **Pebble**	Gravel / **Pebble**	**Gravel** / Pebble	**Gravel** / Pebble	Sand
		0.00	0.15	0.01	0.01	0.00
MS04	Run	**Gravel** / Pebble	**Gravel** / Pebble	**Gravel** / Pebble	**Gravel** / Pebble	**Gravel** / Pebble
		0.00	0.05	0.03	0.23	0.07
XS03	Run	Gravel / **Pebble**	Gravel / **Pebble**	**Gravel** / Pebble	**Gravel** / Pebble	**Gravel** / Pebble
		0.00	0.46	0.15	0.05	0.45
MS05	Glide	Gravel / **Pebble** 0.22	Gravel / **Pebble** 0.29	Gravel / **Pebble** 0.01	**Gravel** / Pebble 0.09	**Gravel** / Pebble 0.22

*Left and right channel margins are defined looking in a downstream direction

***Bold type** indicates whether pebble or gravel sized substrate was dominant.

Gravel-sized sediment is dominant (2-16mm in diameter) in the majority of locations, although pebble-sized material (16-64mm in diameter) is more dominant towards the right hand bank. There is silt present at the channel margins within cross-sections MS01 (right margin) and XS01 (left margin). The latter may be related to sourcing of fine sediment from the drain which enters the river at this point. The left channel margin within cross-sections MS02, XS02 and MS03 is dominated by sand substrate.

Velocity

Flow velocity measurement data is contained within **Appendix D** and summarised for each cross-section in **Table 3.3**. The presence of in-channel islands upstream of cross-section MS01 may be acting to reduce flow velocity in the centre of the channel at this location (**Table 3.2).**

Table 3.3 Velocity summary data

Transect	Physical biotope	Cross-sectional area of flow (m^2)	Mean Velocity (ms^{-1})
MS01	Run	10.72	0.11
XS01	Run	8.84	0.18
MS02	Glide	9.87	0.10
XS02	Glide	9.48	0.09
MS03	Glide	10.22	0.09
MS04	Run	9.24	0.12
XS03	Run	8.27	0.19
MS05	Glide	7.97	0.19
Mean		**9.32**	**0.13**

3.1.2 Biological characteristics

Vegetation structure

In-channel vegetation is present throughout the reach and consists of submerged dicotolydons, including dense areas of brook water-crowfoot (*Ranunuclus pencillatus spp. pseudofluitans*). In-channel vegetation is subject to grazing by swans which is likely to have reduced the natural coverage of some species.

There is a continuous riparian buffer strip along both banks. The left hand bank is semi-continuously treelined, while there are isolated and set bank trees on the right hand bank. Downstream of cross-section MS01, channel narrowing has encouraged a well established fringe of marginal vegetation, consisting predominantly of reed sweet grass (*Glyceria maxima*) on the right hand bank and common reed (*Phragmites australis*) on the left hand bank.

Landuse consists of rough pasture and broadleaved woodland on the left hand bank and recreational use (fisherman's path) and scrub on the right hand bank.

Macrophyte coverage

A total of 66 taxa were recorded during the macrophyte assessment of the site. The locations of the five transects (MS01-MS05), selected to represent different physical biotopes, is illustrated in **Map 3.1**. Each of the transects was also subject to cross-section levelling survey (see Section 3.1.1). The species that were found to be most common within the site, with a coverage of <5 % or more, are listed in **Table 3.4.**

Table 3.4 Macrophyte species coverage (%) within site UWC

Latin Name	Common Name	Macrophyte coverage (%)					
		MS01	MS02	MS03	MS04	MS05	Whole site
		Run	Glide	Glide	Run	Glide	
Key species							
Ranunculus penicillatus spp. Pseudofluitans	Brook water-crowfoot	40	30	40	70	40	40
Callitriche platycarpa	Various-leaved water-starwort	<1	<1	<1	<1	<1	<1
Callitriche stagnalis	Common water-starwort	<1	<5	<1	<5	<1	<1
Oenanthe crocata	Hemlock water dropwort	<1	<1	<1	<5	<5	<5
Species present in <5 %							
Glyceria maxima	Reed sweet-grass	<5	<1	10	10	20	10
Epilobium hirsutum	Great willowherb	<1	<5	<5	<5	<5	<5
Filipendula ulmaria	Meadowsweet	<1	<5	<1		<1	<5
Lycopus europaeus	Gypsywort	<5		<1		<1	<5
Phalaris arundinacea	Reed canary-grass	<5	<1			<1	<5
Phragmites australis	Common reed		<5	10	<1	10	<5
Salix cineria	Grey willow	<5	<5	<5	10	<5	<5
Solanum dulcamara	Bittersweet	<5	<5	<1	<5	<5	<5
Symphytum officinale	Common comfrey	<1	<1	<1	<5		<5
Urtica dioica	Common nettle	<1	<1	<5	<5	<5	<5
Veronica anagallis-aquatica	Blue water-speedwell	<1	<1	<5	10		<5
Zannichellia palustris	Horned pondweed	<5	<1	10	<5	<5	<5
Negative indicators							
None							
Invasive species							
None							
No of Taxa Recorded		**36**	**29**	**31**	**25**	**24**	**66**

At the upstream end of the site (MS01), growth of brook water-crowfoot is greater than 80% on the left hand side of the channel, but scarcer on the right hand side. Horned pondweed (*Zannichellia palustris*) is short and stunted within the reach and appears to be preferentially grazed by swans over brook water-crowfoot (*Ranunuclus pencillatus spp. Pseudofluitans*). Horned pondweed is one of the few submerged vascular plants to be able to tolerate sustained, heavy grazing (Pilkington, pers comm., 2006).

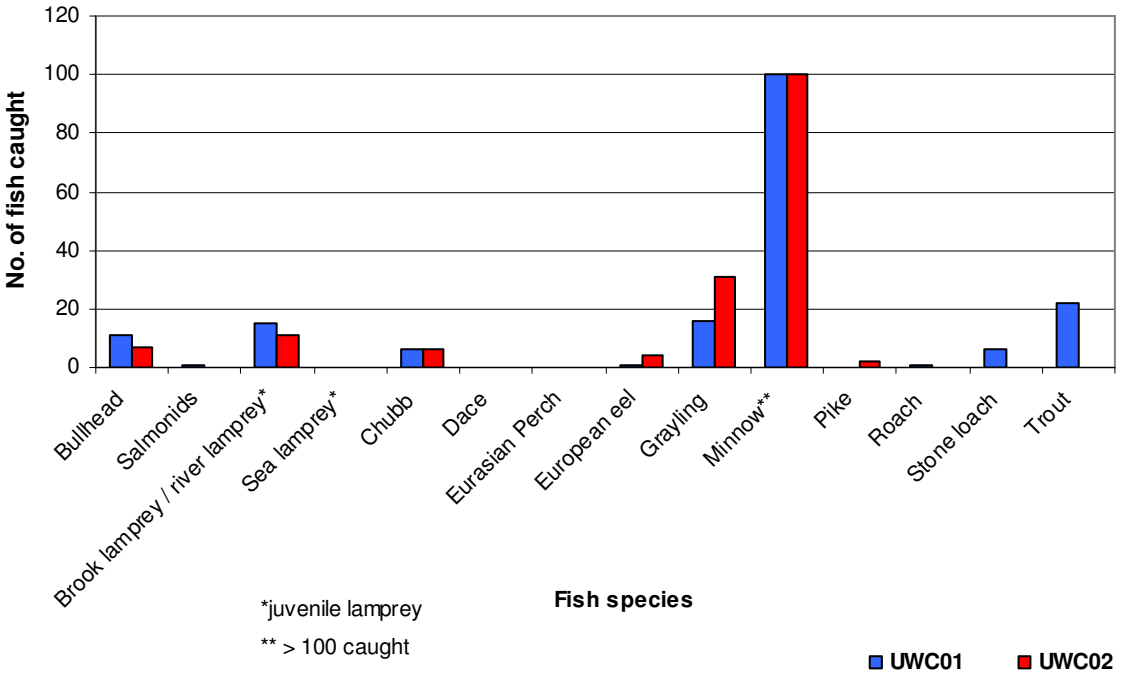
The transition zone between the bank top of the channel and the channel bed has been extended through channel narrowing using willow spilling. This has encouraged extensive growth of various monocotolydon and dicotolydon emergent plants on the bankward side along both banks of the river and is reflected in the diverse range of riparian and marginal species recorded.

Transect MS01 occurs immediately downstream of an artificial island that splits the channel in two. Vegetation on the island is established and dominated by willow tree species. The site contains no negative indicator species or invasive species.

Fisheries survey

Electro-fishing was undertaken at two sites, the locations of which are indicated in **Map 3.1.** The total number of each fish species caught at each site during the electrofishing survey, including the Annex II species for which the Avon SAC is designated, is indicated in **Figure 3.2**.

Figure 3.2 Number of fish caught during electrofishing of sites UWC01 and UWC02



One salmon parr was caught within meso-habitat UWC01. Based on the body length of the parr, this could be either a large 0 year + or a small 1 year + aged fish (Kingcombe Aquacare, 2006).

The calculated minimum density of brook lamprey and bullhead within both of the meso-habitats surveyed is shown in **Table 3.5**.

Table 3.5 Minimum density of brook lamprey and bullhead per m^2.

Fish species		Brook lamprey (quadrats only)		Brook lamprey (quadrat & sweep)		Bullhead	
Meso-habitat		UWC01 (Glide)	UWC02 (Run)	UWC01 (Glide)	UWC02 (Run)	UWC01 (Glide)	UWC02 (Run)
Area		5	5	60	54	800	540
No. fish caught	Shock 1	3	3	3	4	7	4
	Shock 2	1	0	1	0	3	3
	Shock 3	1	0	1	0		
	Total	5	3	5	0	10	7
Minimum density (observed no. per m^2)		1.00	0.60	0.08	0.07	0.013	0.013

There is no significant difference between the minimum density of brook lamprey and bullhead caught during the electrofishing survey of meso-habitats UWC01 and UWC02.

3.1.3 Summary of physical and biological relationships

- Cross-sections surveyed within sections of run physical biotope are wider and shallower at bankfull than cross-sections within glides at this site.
- Water depth is lower through sections of run physical biotope than through glides within this site.
- The most extensive transect coverage of (*Ranunuclus pencillatus spp. pseudofluitans*) is within a run section of the site (MS04). However, extensive coverage of this species (> 40%) was also observed within glides and other runs.
- There is little difference between the minimum density of brook lamprey and bullhead caught within glide (UWC01) and run (UWC02) meso-habitats.
- A greater number of grayling were caught within the run meso-habitat than the glide meso-habitat surveyed. This may be due to a preference for the greater flow velocities observed within this run (see MS02 and XS02) in comparison with the glide (see MS04 and XS03).

3.2 Upper Woodford Restoration Site (UWR)

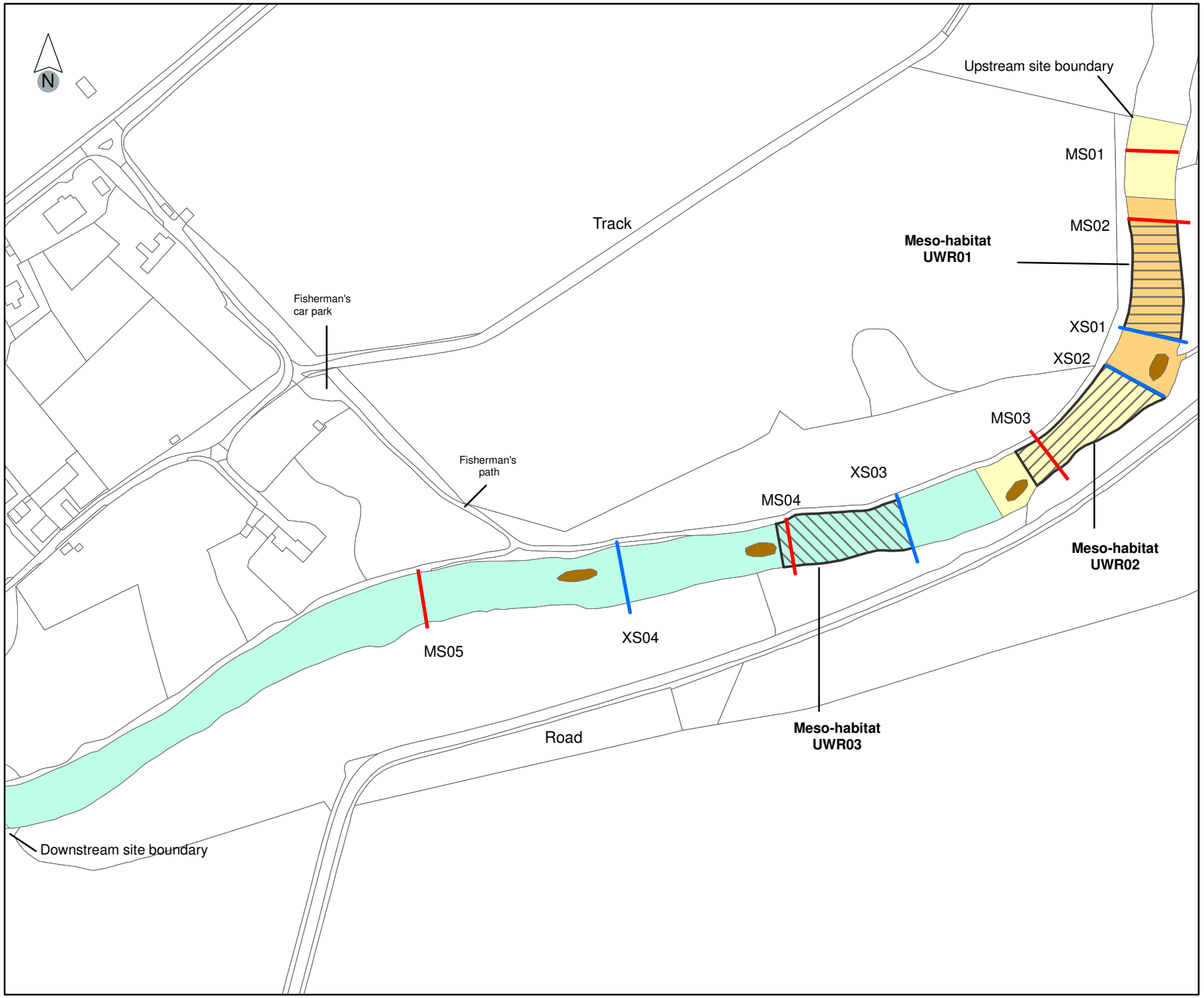
Upstream limit: 413181 137563
Downstream limit: 413067 137896
Length of site: 734m

Location:
The site is located downstream of the boundary fencing on the right hand bank. A mown fisherman's path exists along the right hand bank. The downstream boundary of the site is at the boundary fencing on the right hand bank, upstream of The Bridge Inn public house.

Typical photographs:

Photo UWR01-MS02c: Run biotope at upstream end of site UWR, looking downstream.

Photo UWR03b: Glide biotope looking downstream towards third and fourth in-channel islands.



Legend

Physical biotope

- Run
- Glide (rippled)
- Glide (laminar)
- Existing Islands

Cross-section locations

- Macrophyte transects (MS)
- Additional cross-sections (XS)

Fisheries meso-habitat

- UWR01
- UWR02
- UWR03

Title:
Upper Woodford Restoration Site (UWR)
Physical biotopes and survey references.

Project:
Avon STREAM Monitoring Project

Client:
Natural England

Date:
27/11/2006

Scale:
1:2,500

Map 3.2

ROYAL HASKONING

3.2.1 Physical Characteristics

Physical biotopes

One run and three glides were recorded within the site during the physical biotype mapping survey. At the upstream end of the site an alternating run-glide pattern is observed, similar to that found upstream within the control site, which provides varied flow conditions (**Map 3.2**). Downstream of the second glide, flow becomes uniformly laminar and increasingly slow as the channel becomes deeper and wider.

Sediment regime

The Fluvial Audit recorded no evidence of natural channel adjustment through erosion (see **Appendix A**). Localised fine sediment sourcing is occurring from the right hand bank as a result of access to the channel for fishing purposes. A drain entering the channel from the left hand bank at the meander bend also acts as a source of fine sediment. Deposition of silt on the channel bed was observed downstream of cross-section XS03. The depth of silt increases with distance downstream as the channel becomes deeper.

Physical channel form

Levelling survey was conducted at nine cross-sections, the location of which is illustrated in **Map 3.2**. **Table 3.6** provides summary data for each of the cross-sections surveyed.

Table 3.6 Cross-sectional summary data

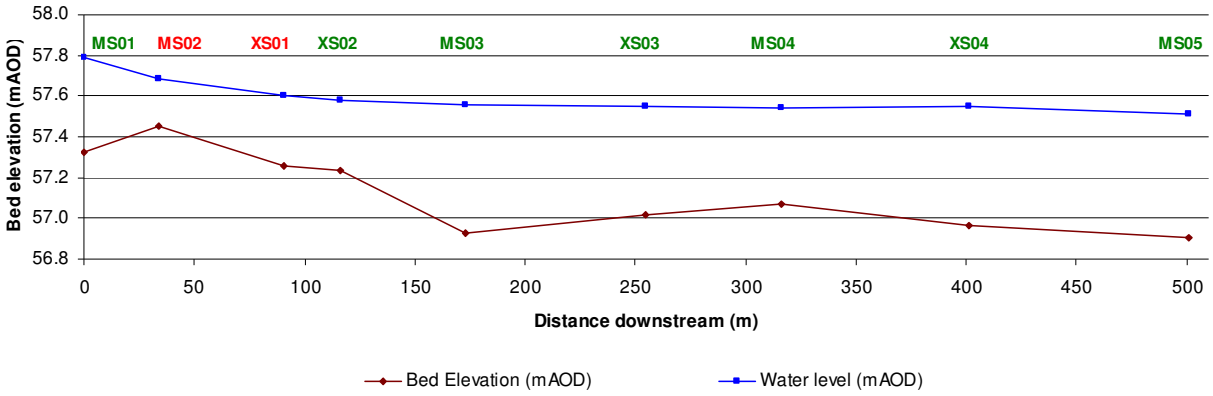
Transect	Physical biotope	Bankfull width (m)	Bankfull depth (m)	Width:depth ratio	Water width (m)	Water depth (m)
MS01	Glide	20.51	0.76	26.9	16.68	0.47
MS02	Run	26.03	0.67	38.6	24.36	0.23
XS01	Run	32.18	0.77	41.8	26.10	0.35
XS02	Run	27.78	0.73	38.1	22.60	0.34
MS03	Glide	21.15	1.01	20.9	16.82	0.63
XS03	Glide	29.10	0.88	33.2	22.92	0.53
MS04	Glide	22.62	0.94	24.0	20.76	0.48
XS04	Glide	30.24	1.03	29.3	22.87	0.58
MS05	Glide	24.96	0.92	27.1	19.42	0.61
Mean		**26.06**	**0.86**	**31.1**	**21.39**	**0.47**

The channel is wide throughout the reach and sections of over 30m wide are found within both run and glide physical biotopes. Of the cross-sections surveyed, those situated within sections of run physical biotope are typically shallower at bankfull, and consequently have a higher width:depth ratio than those situated within sections of glide physical biotope (**Table 4.1**). Water depth is also lower and over a greater width within the run sections of the site.

Downstream of cross-sections XS01, in-channel islands formed of brushwood have been constructed in the channel. There are currently four islands spaced at intervals throughout the site (**Map 3.2).** These islands influence the cross-sectional profiles of cross-sections immediately upstream and downstream (e.g. XS01 and XS02).

The long profile of the channel, derived using the deepest points at each of the cross-sections, is presented in **Figure 3.3**.

Figure 3.3 Long profile derived from cross-sectional data from MS01 to MS05



Over a distance of 501m (between cross-section MS01 and MS05), there is a fall in bed elevation of 0.42m (a gradient of 0.001). The long profile also illustrates that the channel is deeper through the glide sections of the channel in comparison with the run sections at the upstream of the site (MS02 and XS01).

Boundary conditions

The channel banks are shallow ending in a vertical face. The bank is also reinforced semi-continuously by wooden toe boarding along the left hand bank. Where visible the banks are composed of sand/silt material.

Bed substrate samples taken from the channel centre, both channel margins and intervening points (see **Table 3.7**) indicate that the dominant substrate is gravel / pebble material (2-64mm in diameter).

Gravel-sized sediment is dominant (2-16mm in diameter) in the majority of locations, although pebble-sized material (16-64mm in diameter) is dominant along the upstream cross-sections. Sand is present along the left hand side of the channel within cross-sections XS01 and XS02. This may be associated with fine sediment sourcing from the drain that enters the channel from the left hand bank in this location.

Gravel / pebble material is overlain by superficial silt at cross-section MS03 and all sections further downstream. The layer of silt becomes thicker with distance downstream and is the dominant substrate at cross-sections MS04 and MS05.

Table 3.7 Bed substrate and flow velocities sampled at surveyed cross-sections*

Transect	Physical biotope	Right channel margin	Right of channel centre	Channel centre	Left of channel centre	Left channel margin
MS01	Glide	Gravel / **Pebble**	Gravel / **Pebble**	**Gravel** / Pebble	**Gravel** / Pebble	**Gravel** / Pebble
		0.58	0.17	**0.06**	**0.02**	**0.01**
MS02	Run	Gravel / **Pebble**	Gravel / **Pebble**	Gravel / **Pebble**	Gravel / **Pebble**	**Gravel** / Pebble
		0.13	0.34	0.35	0.32	0.00
XS01	Run	**Gravel** / Pebble	**Gravel** / Pebble	Sand	Sand	Sand
		0.16	0.21	0.15	0.10	0.00
XS02	Run	**Gravel** / Pebble	**Gravel** / Pebble	**Gravel** / Pebble	Sand	**Gravel** / Pebble
		0.03	0.19	0.15	0.04	**0.00**
MS03	Glide	**Gravel** / Pebble	**Gravel** / Pebble	**Gravel** / Pebble	**Gravel** / Pebble	**Gravel** / Pebble
		0.01	0.17	0.18	0.15	0.00
XS03	Glide	**Gravel** / Pebble	**Gravel** / Pebble	**Gravel** / Pebble	**Gravel** / Pebble	Silt
		0.00	0.07	0.01	0.12	0.01
MS04	Glide	Silt	**Gravel** / Pebble	Silt	**Gravel** / Pebble	Silt
		0.01	0.05	0.04	0.06	0.00
MS05	Glide	Silt	Silt	Silt	Silt	Silt
		0.01	0.02	0.04	0.05	0.00

*Left and right channel margins are defined looking in a downstream direction

****Bold type** indicates whether pebble or gravel sized substrate was dominant.

Velocity

Flow velocity measurement data is contained within **Appendix D** and summarised for each cross-section in **Table 3.8**. Downstream of the run physical biotope, the cross-sectional area of flow increases, while mean velocity decreases. This reflects the deepening of the cross-sectional profile of the channel and impoundment due to the hatches further downstream.

Table 3.8 Velocity and discharge summary data for site UWR

Transect	Physical biotope	Cross-sectional area of flow (m^2)	Mean Velocity (ms^{-1})
MS01	Glide	6.24	0.16
MS02	Run	4.71	0.29
XS01	Run	7.12	0.13
XS02	Run	6.18	0.14
MS03	Glide	7.13	0.13
XS03	Glide	8.99	0.07
MS04	Glide	8.88	0.04
XS04	Glide	9.28	Not measured
MS05	Glide	9.26	0.03
Mean		**7.53**	**0.12**

3.2.2 Biological characteristics

Vegetation structure
In-channel vegetation is present throughout the site although the coverage of different species changes with distance downstream. Towards the downstream boundary of the site, fennel pondweed (*Potomageton pectinatus*) is present. In-channel vegetation is subject to grazing by swans which is likely to have reduced the natural coverage of some species.

There is a continuous riparian buffer strip along both banks. The left hand bank is semi-continuously treelined, while there are isolated and set bank trees on the right hand bank. The width of the riparian zone on the right hand bank is constrained by the presence of a mown fisherman's path along this bank. The marginal fringes of both banks contain reed sweet grass (*Glyceria maxima*), greater pond sedge (*Carex riparia*) and common reed (*Phragmites australis*).

Landuse consists of broadleaved woodland on the left hand bank and recreational use (fisherman's path), unimproved grassland, wetland and scrub on the right hand bank.

Macrophyte coverage
A total of 88 taxa were recorded during the macrophyte assessment of the site. The locations of the 5 transects surveyed (MS01-MS05) were selected to represent different physical biotopes (see **Map 3.2**). Each transect was also subject to cross-section levelling survey (see Section 3.2.1).

Key species and those species that there were found to be most common within the site, with a coverage of <5 % or more, are listed in **Table 3.9.** The site contains one negative indicator species (*Potomageton pectinatus*) and one invasive species (*Impatiens glandulifera*),.

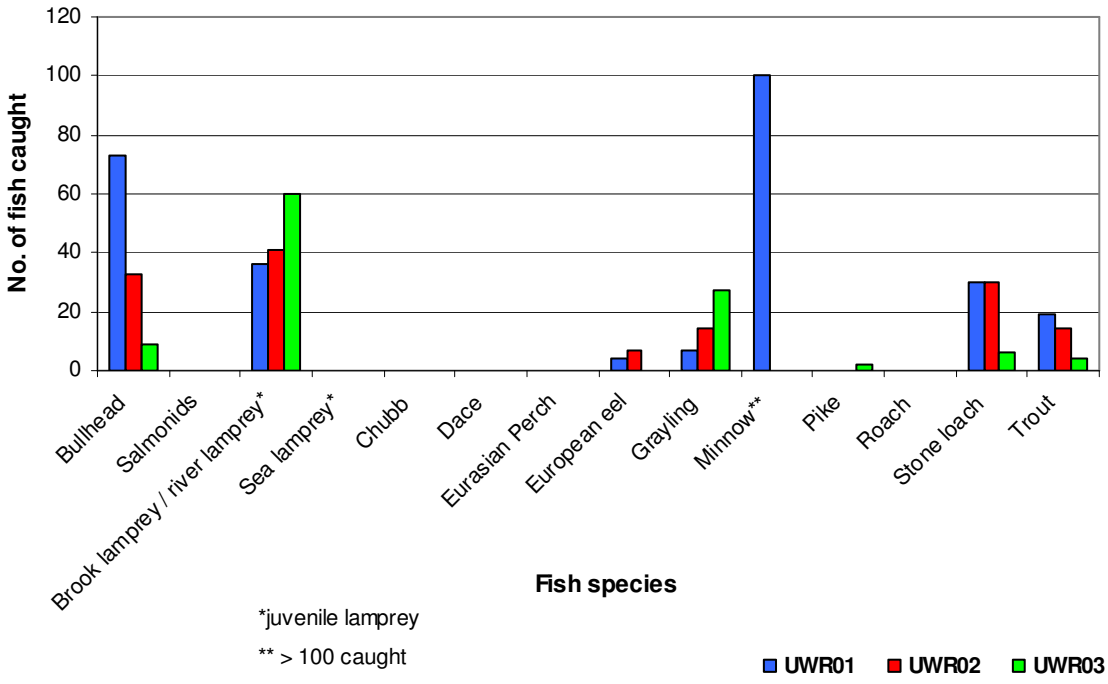
Growth of brook water-crowfoot (*Ranunuclus pencillatus spp. pseudofluitans*) is extensive at the upstream end of the site (MS01). Horned pondweed (Zannichellia palustris) is also frequent upstream of the second in-channel island, but is short and stunted within the reach and appears to be preferentially grazed over the brook water-crowfoot. Further downstream, fennel pondweed (*Potamogeton pectinatus*) becomes the most frequently occurring submerged macrophyte indicating deterioration in habitat conditions.

Fisheries survey
Electro-fishing was undertaken at three sites, the location of which is indicated in **Map 3.2.** The total number of each fish species caught at each site during the electrofishing survey, including the Annex II species for which the Avon SAC is designated, is indicated in **Figure 3.4**.

Table 3.9 Macrophyte species coverage (%) within site UWR

Latin Name	Common Name	Macrophyte coverage (%)					
		MS01	MS02	MS03	MS04	MS05	Whole site
		Glide	Run	Glide	Glide	Glide	
Key species							
Ranunculus penicillatus spp. Pseudofluitans	brook water-crowfoot	40	<5	10	<1		<5
Callitriche platycarpa	various-leaved water starwort		<1	<1			<1
Callitriche stagnalis	common water starwort	<1	<1		<1		<1
Oenanthe crocata	hemlock water dropwort					<1	<1
Species present in <5 %							
Carex riparia	greater pond sedge			10		10	20
Epilobium hirsutum	great willow herb	<5	10		<5	<1	<5
Filipendula ulmaria	meadow sweet	<1	<1			<1	<5
Glyceria maxima	reed sweet grass						<5
Lythrum salicaria	purple loosestrife		<5			<1	<5
Phalaris arundinacea	reed-canary grass	<5	10	10	<5	<1	<5
Phragmites australis	common reed		10	<5			<5
Pulicaria dysenterica	common fleabane	<5	<5	<1	<5	<1	<5
Salix cinerea	grey willow						<5
Sparganium erectum	branched bur-reed		<1	<5	<1		<5
Symphytum officinale	common comfrey	<5			<1	<1	<5
Urtica dioica	common nettle	<5	<5			<1	<5
Zannichellia palustris	horned pondweed	30	10	10			<5
Negative indicators							
Potamogeton pectinatus	fennel pondweed					<1	<1
Invasive species							
Impatiens glandulifera	Himalayan balsam						<1
No of Taxa Recorded		**27**	**33**	**18**	**23**	**27**	**88**

Figure 3.4 Number of fish caught during electofishing of sites UWR01, UWR02 and UWR03.



The calculated minimum density of brook lamprey and bullhead within both of the meso-habitats surveyed is shown in **Table 3.10**.

Table 3.10 Minimum density of brook lamprey and bullhead per m^2.

Fish species		Brook lamprey (quadrats only)			Brook lamprey (quadrat & sweep)			Bullhead		
Meso-habitat		UWR01 (Run)	UWR02 (Glide)	UWR03 (Glide)	UWR01 (Run)	UWR02 (Glide)	UWR03 (Glide)	UWR01 (Run)	UWR02 (Glide)	UWR03 (Glide)
Area		5	5	5	27	22	22	1377	1200	1100
No. fish caught	Shock 1	5	12	12	7	12	12	31	10	3
	Shock 2	4	3	13	4	3	13	18	23	6
	Shock 3	3	7	10	3	7	10			
	Total	12	22	35	14	22	35	49	33	9
Minimum density (observed no. per m^2)		2.40	4.40	7.00	0.52	1.00	1.59	0.036	0.028	0.008

Table 3.10 indicates that while the observed minimum density of brook lamprey is greater within the glide meso-habitats, the observed minimum density of bullhead is greatest within the run meso-habitat.

3.2.3 Physical and biological relationships

- The cross-sections surveyed within sections of glide physical biotope are deeper at bankfull than cross-sections within the run at this site.

- Flow velocity and calculated discharge decreases with distance downstream through the reach while siltation increases. This is likely to be due to the increasing influence of flow impoundment resulting from the hatches downstream.

- Brook water-crowfoot (*Ranunuclus pencillatus spp. pseudofluitans*) and horned pondweed (*Zannichellia palustris*) are extensive within the most upstream transect surveyed (MS01). Coverage of both of these species declines with distance downstream while coverage of fennel pondweed (*Potomageton pectinatus*) increases. These trends are likely to be related to increasing flow depth, decreasing flow velocities and increasing siltation.

- The greatest density of bullhead was observed within the upstream run physical biotope. This is likely to reflect a preference for faster flow velocities and clean substrate without the presence of overlying silt.

- The greatest density of lamprey was found within the downstream glide meso-habitat. This may reflect their preference for marginally silted habitat conditions.

3.3 Seven Hatches Control Site (SHC)

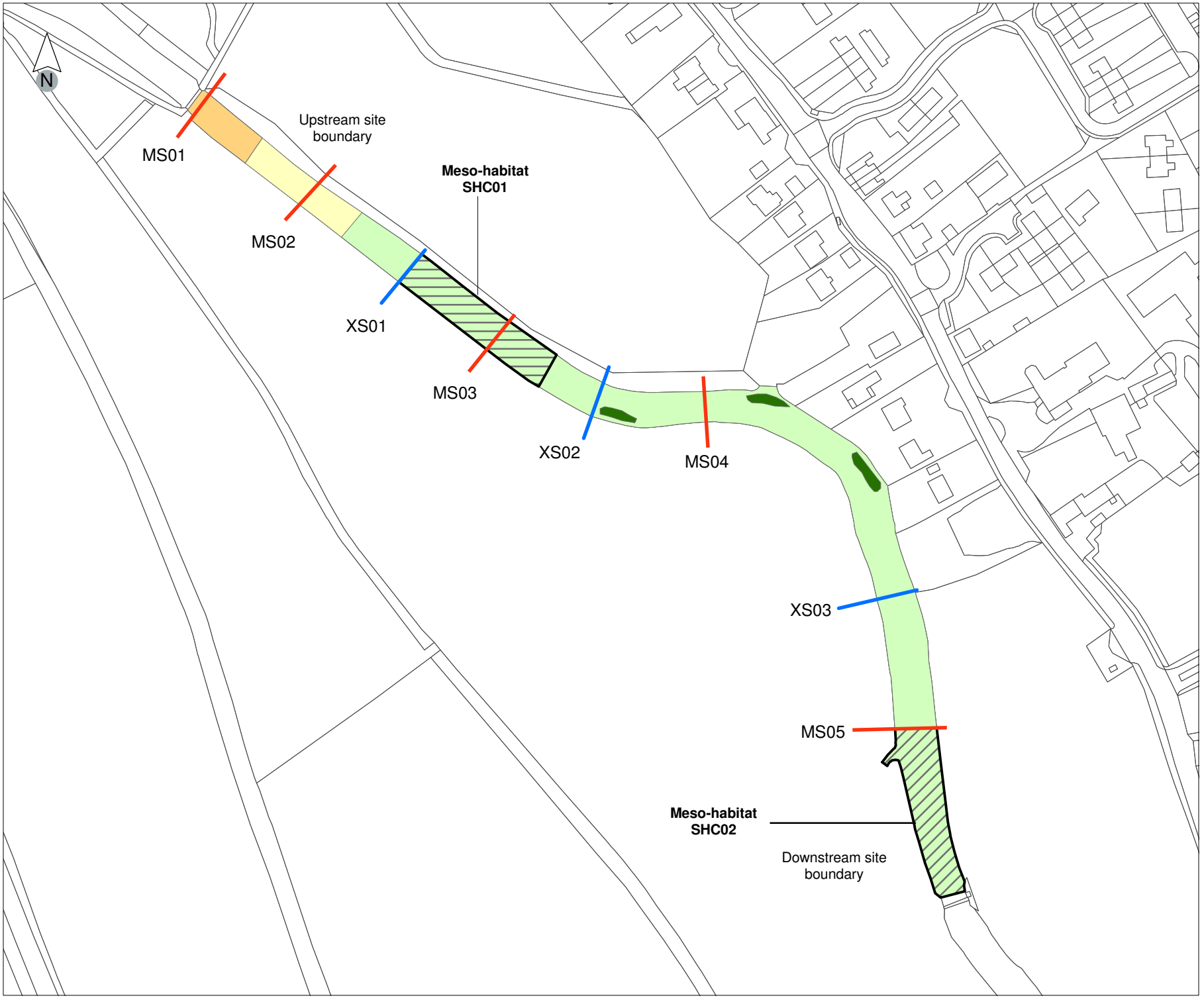
Upstream limit: 408307 134584
Downstream limit: 408628 134264
Length of site: 512m

Location:
The site is located alongside the village of South Newton upstream of South Newton gauging weir. The upstream site boundary is a footbridge across the river. The downstream site boundary is upstream of the gauging weir itself (**Map 3.3)**. The control site is some distance upstream of the restoration site (see the Monitoring Protocol which describes site selection).

Typical photographs:

Photo SHC01a:
Looking downstream from footbridge over "riffle" and glide physical biotopes.

Photo SHC02b:
Looking across deep channel towards private gardens on left hand bank.



Legend

Physical biotope

- Riffle
- Glide (rippled)
- Glide (laminar)
- Pool

Cross-section locations

- Macrophyte transects (MS)
- Additional cross-sections (XS)

Fisheries meso-habitat

- SHC01
- SHC02

Title:
Seven Hatches Control Site (SHC)
Physical biotopes and survey references

Project:
Avon STREAM Monitoring Project

Client:
Natural England

Date:
29/11/2006

Scale:
1:2,081

Map 3.3

ROYAL HASKONING

3.3.1 Physical Characteristics

Physical biotopes

One riffle and two glides were recorded within the site during the Physical Biotype Mapping survey. The riffle is present immediately downstream of the footbridge which marks the upstream boundary of the site (**Map 3.3**). Downstream of the riffle there is a glide within which the water surface is rippled. The second glide is located downstream of a deflector comprised of paving slabs. Flow becomes laminar within this section and deeper pools are located along the outer edges of the meander bend.

Sediment regime

The Fluvial Audit recorded no evidence of natural channel adjustment through erosion (see **Appendix A**). Both banks are protected by willow spiling, which is continuous along the right hand bank upstream of the private gardens (**Map 3.3)** and prevents bank erosion. Eight small deflectors comprised of posts with wire netting in between, have also been installed along this section (two on the left hand bank and six on the right hand bank) in order to narrow the channel by encouraging deposition and marginal vegetation growth. A larger deflector made of paving slabs is located on the inside of the first meander bend. Downstream of the paved deflector (see **Map 3.3**), channel modification has contributed to a steep vertical bank on the inside of the meander bend. The channel is overdeep and deposition of silt is occurring on the channel bed. The depth of silt increases with distance downstream due impoundment of flows upstream of South Newton gauging weir.

Physical channel form

Levelling survey was conducted at eight cross-sections, the location of which is illustrated in **Map 3.3**. **Table 3.11** provides summary data for each of the cross-sections surveyed.

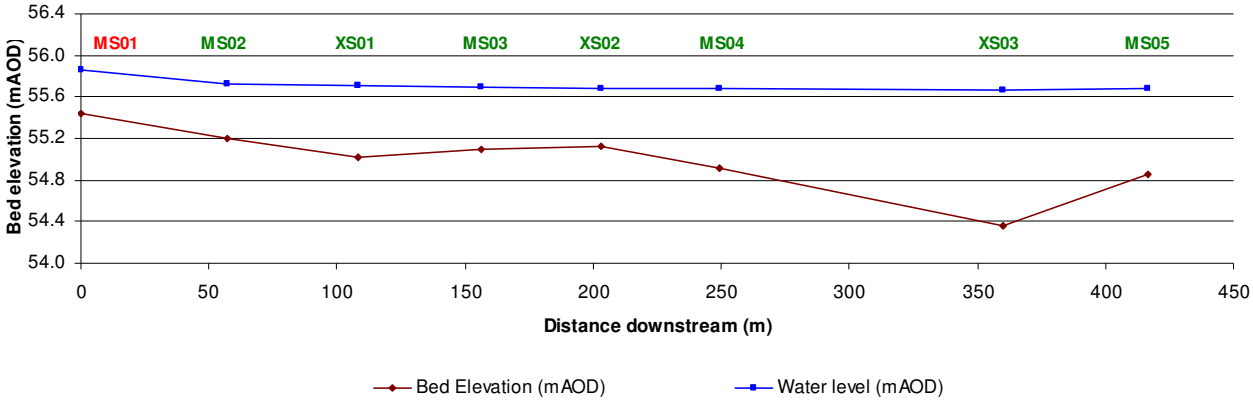
Table 3.11 Cross-sectional summary data for site SHC

Transect	Physical biotope	Bankfull width (m)	Bankfull depth (m)	Width:depth ratio	Water width (m)	Water depth (m)
MS01	Riffle	20.69	1.05	19.7	16.39	0.42
MS02	Glide	20.72	0.95	21.8	10.42	0.52
XS01	Glide	13.09	0.80	16.4	10.10	0.69
MS03	Glide	15.81	1.02	15.5	10.77	0.61
XS02	Glide	20.48	1.29	15.9	15.81	0.56
MS04	Glide	18.62	1.23	15.1	15.73	0.77
XS03	Glide	15.40	1.75	8.8	13.51	1.31
MS05	Glide	19.40	1.49	13.0	14.93	0.82
Mean		**18.03**	**1.20**	**15.77**	**13.46**	**0.71**

The channel is embanked on the right hand bank and of relatively uniform width throughout the site. The channel is shallowest at the most upstream cross-sections (MS01 and MS02) and particularly deep at cross-section XS03, which is located across a pool.

The long profile of the channel, derived using the deepest points at each of the cross-sections, is presented in **Figure 3.5**.

Figure 3.5 Long profile



Over a distance of 416m (between cross-section MS01 and MS05), there is a fall in bed elevation of 0.59m (a gradient of 0.001). The long profile illustrates the uniformity of bed elevation and water depth upstream of cross-section MS04 and how the channel deepens downstream as it flows around the meander bend. The cross-sectional profile of the channel downstream of MS04 is overdeep in comparison with the channel upstream.

Boundary conditions

The channel banks are steeply graded and embanked along the right hand bank. Where visible the banks were observed to be composed of sand/silt material. Upstream of cross-section MS04 the toe of the bank is protected by willow spiling.

Bed substrate samples taken from the channel centre, both channel margins and intervening points (see **Table 3.12**) indicate that the dominant substrate is gravel / pebble material (2-64mm in diameter).

Pebble-sized material (16-64mm in diameter) is dominant within the riffle section at the upstream end of the site. Gravel-sized sediment becomes dominant within the rippled glide immediately downstream (2-16mm in diameter). Silt is present along the left hand bank downstream of cross-section XS01. Between cross-sections XS01 and XS02 this may be related to the deflectors that have been installed along the left hand bank. Further downstream silt is present along both channel margins and is likely be related to the overdeep nature of the cross-sectional profile in comparison with the channel upstream.

Table 3.12 Bed substrate and flow velocities sampled at surveyed cross-sections*

Transect	Physical biotope	Right channel margin	Right of channel centre	Channel centre	Left of channel centre	Left channel margin
MS01	Riffle	Gravel / **Pebble**	Gravel / **Pebble**	Gravel / **Pebble**	Gravel / **Pebble**	Gravel / **Pebble**
		0.00	0.31	0.41	0.18	0.00
MS02	Glide	**Gravel** / Pebble	**Gravel** / Pebble	**Gravel** / Pebble	**Gravel** / Pebble	**Gravel** / Pebble
		0.01	0.16	0.32	0.13	0.00
XS01	Glide	**Gravel** / Pebble	**Gravel** / Pebble	**Gravel** / Pebble	**Gravel** / Pebble	Silt
		0.00	0.12	0.16	0.13	0.00
MS03	Glide	**Gravel** / Pebble	**Gravel** / Pebble	**Gravel** / Pebble	**Gravel** / Pebble	Silt
		0.01	0.13	0.13	0.13	0.00
XS02	Glide	**Gravel** / Pebble	**Gravel** / Pebble	**Gravel** / Pebble	**Gravel** / Pebble	Silt
		0.00	0.20	0.22	0.10	0.00
MS04	Glide	**Gravel** / Pebble	**Gravel** / Pebble	**Gravel** / Pebble	**Gravel** / Pebble	Silt
		0.00	0.11	0.23	0.01	0.00
XS03	Glide	Silt	Silt	**Gravel** / Pebble	**Gravel** / Pebble	Silt
		0.00	0.06	0.01	0.00	0.00
MS05	Glide	Silt	**Gravel** / Pebble	**Gravel** / Pebble	**Gravel** / Pebble	Silt
		0.00	0.04	0.04	0.02	0.00

*Left and right channel margins are defined looking in a downstream direction

****Bold type** indicates whether pebble or gravel sized substrate was dominant.

Velocity

Flow velocity measurement data is contained within **Appendix D** and summarised for each cross-section in **Table 3.13.**

Table 3.13 Velocity summary data

Transect	Physical biotope	Cross-sectional area of flow (m^2)	Mean Velocity (ms^{-1})
MS01	Riffle	4.04	0.33
MS02	Glide	4.52	0.20
XS01	Glide	5.69	0.12
MS03	Glide	5.78	0.10
XS02	Glide	4.79	0.16
MS04	Glide	6.33	0.10
XS03	Glide	12.27	0.05
MS05	Glide	9.04	0.03
Mean		**6.56**	**0.14**

Flow velocity is highest within the upstream riffle section (**Table 3.13**). Along the downstream glide (MS02 - XS02) flow velocity is lower but remains relatively constant. From cross-section MS04 downstream there is a distinct decrease in flow velocity which reflects the larger cross-sectional area of flow and influence of impoundment on this section.

3.3.2 Biological characteristics

Vegetation structure
In-channel vegetation is present but limited in its coverage within the site. Grazing by swans (and geese) is extensive downstream of the footbridge (transects MS01 and MS02), with correspondingly stunted growth of submerged macrophytes, particularly horned pondweed (*Zannichellia palustris*).

The channel has a short marginal transition zone due to the steep bank gradient and embankment of the channel along the right hand bank. However, where willow spiling is present it has enabled emergent species to readily colonise the channel margins. Dredging has resulted in a steep vertical right bank face on the inside of the meander bend downstream of cross-section MS03. This bank has been colonised by water voles.

The adjacent landuse is semi-improved grassland / private gardens on the left hand bank and arable on the right hand bank. The embankment on the right hand bank is colonised by ruderal species, in particular common nettle (*Utrica dioica*), which indicate high nutrient levels. This is likely to be due to the soil type and crop grown (reported by the river keeper to historically have been maize but this year is oil seed rape), which requires nutrient enrichment. There are isolated trees along the right bank and occasional clumps on the left bank, becoming treelined downstream of private gardens.

Macrophyte coverage
A total of 68 taxa were recorded during the macrophyte assessment of the site. The locations of the five transects surveyed (MS01-MS05) were selected to represent different physical biotopes (see **Map 3.3**). Each of the transects was also subject to cross-section levelling survey (see Section 3.3.1).

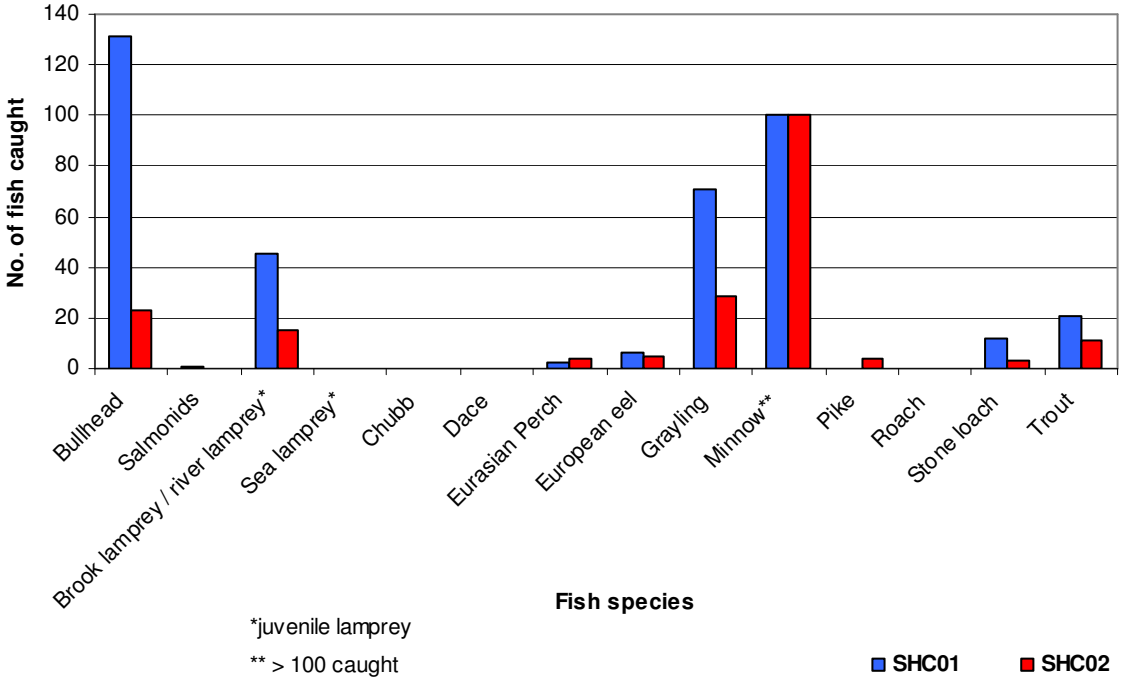
The species found to be most common within the site, with a coverage of <5 % or more, are listed in **Table 3.14.** The site contains only one negative indicator species and no invasive species. The highest coverage of brook water-crowfoot (*Ranunuclus pencillatus spp. pseudofluitans*) was found within transect MS01, which crosses the “riffle” physical biotope. Further downstream the presence of fennel pondweed (*Potamogeton pectinatus*) is a negative vegetation habitat indicator, although brook water-crowfoot was also found within transect MS04. The greatest number of macrophyte species were identified within transect MS02.

Fisheries survey
Electro-fishing was undertaken at two sites, the location of which is indicated in **Map 3.3.** The total number of each fish species caught at each site during the electrofishing survey, including the Annex II species for which the Avon SAC is designated, is indicated in **Figure 3.6**.

Table 3.14 Macrophyte species coverage (%) within site SHC

Latin Name	Common Name	Macrophyte coverage (%)					
		MS01	MS02	MS03	MS04	MS05	Whole site
		Run	Glide	Glide	Glide	Glide	
Key species							
Ranunculus penicillatus spp. pseudofluitans	brook water crowfoot	20	<1	<1	10	<1	10
Callitriche obtusangula	blunt-fruited water starwort		<1		<1		<1
Oenanthe crocata	hemlock water dropwort	<1		<1			<5
Species present in <5 %							
Epilobium hirsutum	great willow herb	<5	<5	10	<1	<5	10
Potentilla anserina	silverweed						10
Sparganium erectum	branched bur-reed		10	<1		<5	10
Alnus glutinosa	alder						<5
Arrhenatherum elatius	false oat-grass						<5
Calystegia sepium	hedge bindweed	10	<1		<1	<1	<5
Carex riparia	greater pond sedge					<5	<5
Persicaria amphibia	amphibious bistort			<1			<5
Populus nigra	black poplar						<5
Salix alba	white willow						<5
Scrophularia auriculata	water figwort	<1	<1	<1	<5		<5
Symphytum officinale	common comfrey		<1			<1	<5
Urtica dioica	common nettle	10	10	<1	<1	<5	<5
Negative indicators							
Potamogeton pectinatus	fennel pondweed		10		10	<1	10
Invasive species							
None							
No of Taxa Recorded		**16**	**29**	**17**	**20**	**20**	**68**

Figure 3.6 **Number of fish caught during electofishing of sites SHC01 and SHC02**



One salmon parr was caught within meso-habitat SHC01. Based on the body length of the parr, this could be either a large 0 year + or a small 1 year + aged fish (Kingcombe Aquacare, 2006).

The calculated minimum density of brook lamprey and bullhead within both of the meso-habitats surveyed is shown in **Table 3.15**.

Table 3.15 **Minimum density of brook lamprey and bullhead per m^2.**

Fish species		**Brook lamprey (quadrats only)**		**Brook lamprey (quadrat & sweep)**		**Bullhead**	
Meso-habitat		**SHC01 (Glide)**	**SHC02 (Glide)**	**SHC01 (Glide)**	**SHC02 (Glide)**	**SHC01 (Glide)**	**SHC02 (Glide)**
Area		**5**	**5**	**20**	**20**	**1740**	**1000**
No. fish caught	**Shock 1**		5		5	74	15
	Shock 2	1	2	1	2	57	8
	Shock 3	2	8	2	8		
	Total	3	15	3	15	131	23
Minimum density (observed no. per m^2)		**0.60**	**3.00**	**0.15**	**0.75**	**0.075**	**0.023**

Table 3.15 indicates that the observed minimum density of bullhead is greatest within meso-habitat SHC01. **Figure 3.6** also indicates that a greater number of stone loach and trout were caught within meso-habitat SHC01. This may indicate preference of bullhead, trout and grayling for the shallower, higher velocity flow conditions found within meso-habitat SHC01 in comparison with SHC02.

In contrast, the observed minimum density of brook lamprey caught within the quadrat survey is greater within meso-habitat SHC02. This may indicate preferential use of habitat containing silt for spawning. However, **Figure 3.6** indicates that a greater number of brook lamprey were caught within meso-habitat SHC01 when the fish caught during the netted survey are taken into account.

3.3.3 Physical and biological relationships

- The physical characteristics of the site can be divided into two contrasting sections.
- In the upper section (MS01-XS02) the channel is shallower and flow velocities are greater than further downstream. Flow velocities decline and the cross-sectional area of flow and influence of impoundment increases upstream of South Newton gauging weir.
- The coverage of macrophyte species indicates deterioration in vegetation habitat conditions downstream of the riffle at MS01 with fennel pondweed (*Potamogeton pectinatus*) becoming more extensive in the downstream sections of the site.
- The density of bullhead is greatest within the upstream glide meso-habitat. This may reflect a preference for faster flow velocities and a substrate with less overlying silt.
- The density of brook lamprey is greatest within the downstream glide meso-habitat. This is consistent with known habitat preferences of juvenile lamprey.

3.4 Seven Hatches Restoration Site (SHR)

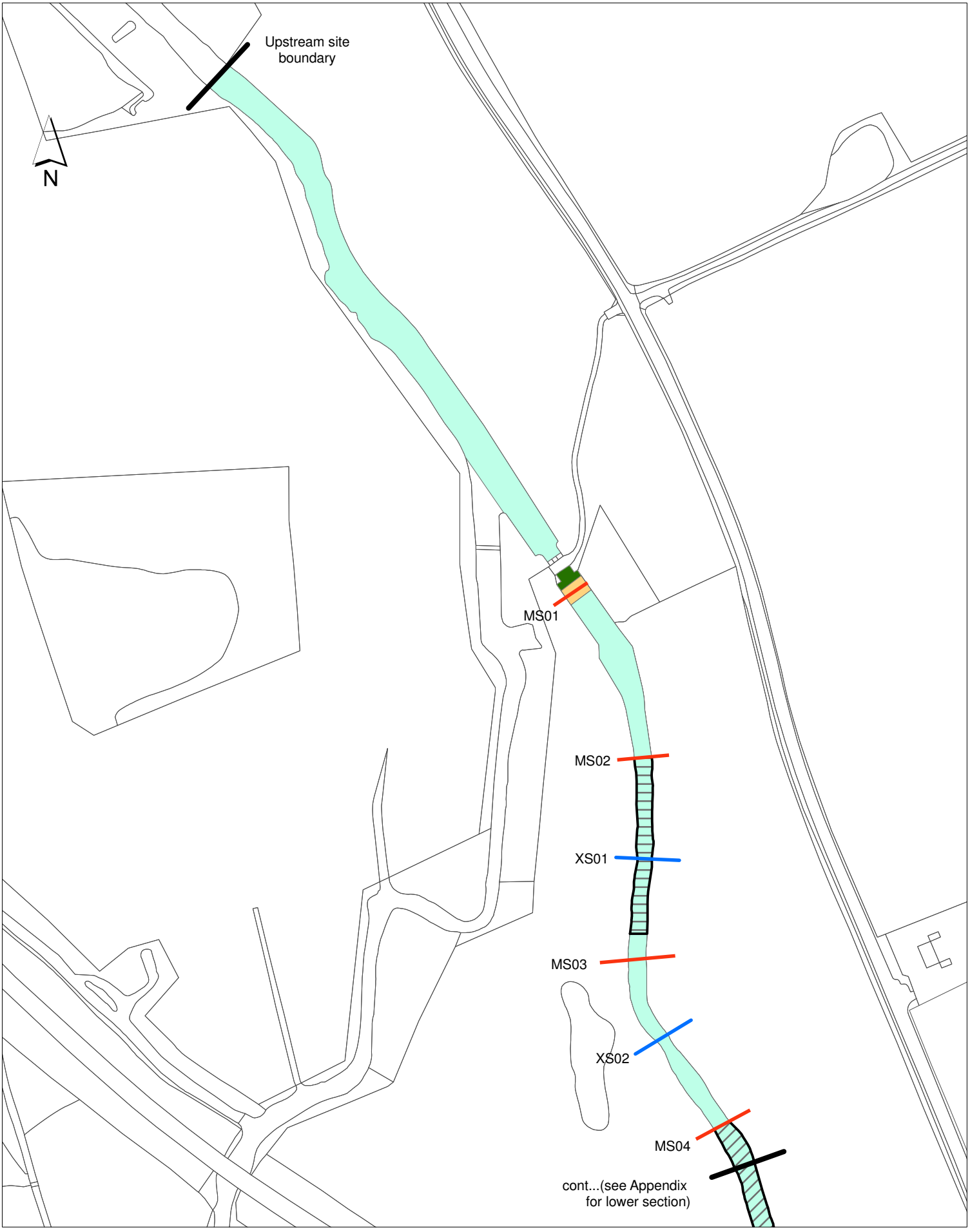
Upstream limit: 409357 132978
Downstream limit: 409849 131814
Length of site: 1329m

Location:
The site is located downstream of Chilhampton Farm and includes the impounding structure known as Seven Hatches. The upstream site boundary is the fence downstream of the footbridge (**Maps 3.4a and 3.4b**). The downstream site boundary is the tractor bridge located upstream of the second railway crossing. Due to the length of this site, detailed survey techniques have been focussed on the section downstream of the Seven Hatches and upstream of the first railway crossing (**Map 3.4a and 3.4b**).

Typical photographs:

Photo SHR02f:
Looking downstream along uniform glide section downstream of the Seven Hatches structure.

Photo SHR04g:
Looking downstream along uniform glide downstream of the first railway crossing.



Legend

Physical biotope
- Riffle
- Glide (laminar)
- Pool

Fisheries mesohabitats
- SHR01
- SHR02

Cross-section locations
- Macrophyte transect (MS)
- Additional cross-sections (XS)

Title: Seven Hatches Restoration Site (SHR)
Physical biotopes and survey references

Project: Avon STREAM Monitoring Project

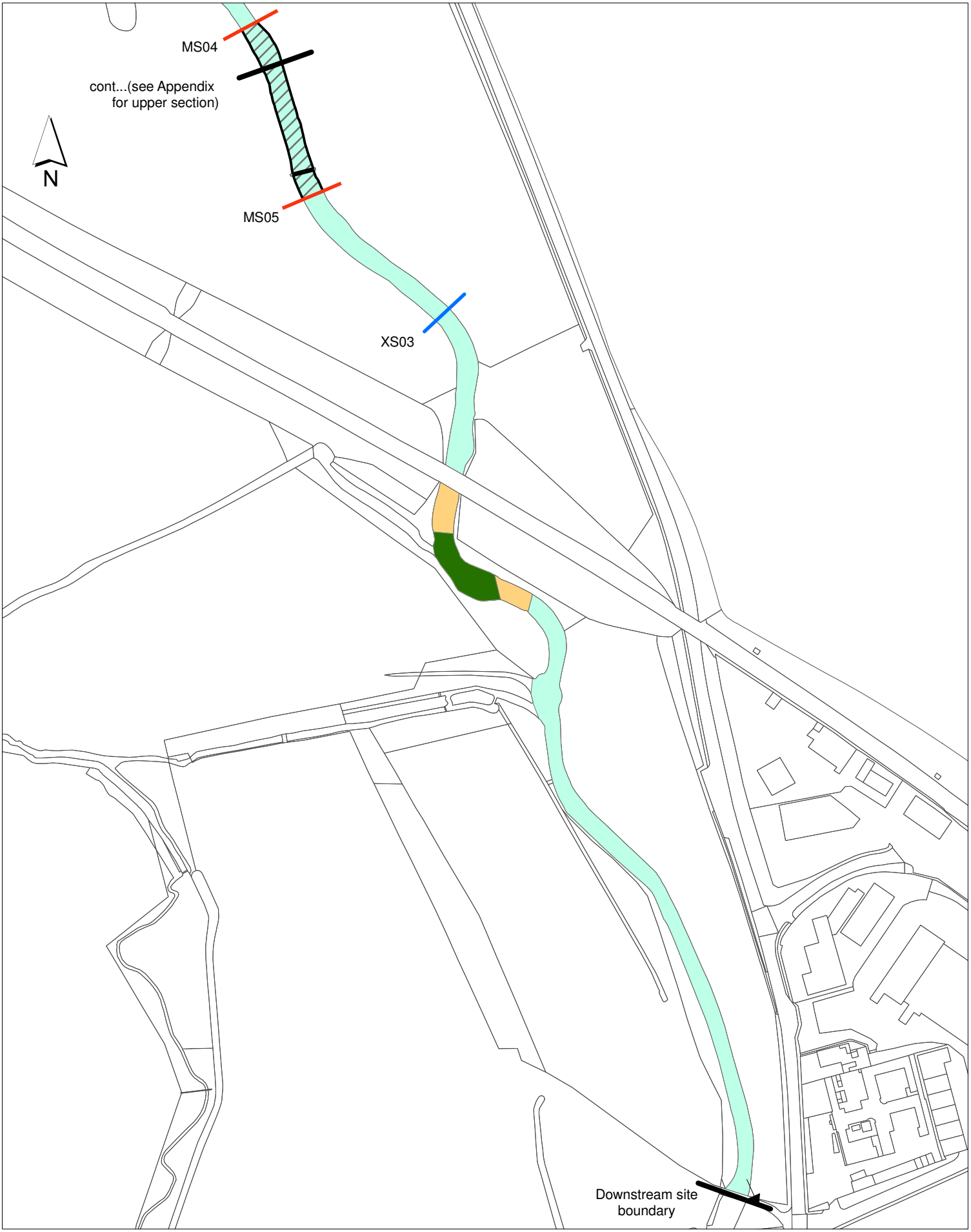
Client: Natural England

Date: 29/11/2006

Scale: 1:2,500

Map 3.4a

ROYAL HASKONING



Legend

Physical biotope
- Riffle
- Glide (laminar)
- Pool

Fisheries mesohabitats
- SHR01
- SHR02

Cross-section locations
- Macrophyte transect (MS)
- Additional cross-sections (XS)

Title: Seven Hatches Restoration Site (SHR)
Physical biotopes and survey references

Project: Avon STREAM Monitoring Project

Client: Natural England

Date: 29/11/2006

Scale: 1:2,500

Map 3.4b

ROYAL HASKONING

3.4.1 Physical Characteristics

Physical biotopes

This majority of site is comprised of sections of glide physical biotope (**Map 3.4a and 3.4b**), separated by the Seven Hatches and railway crossing structures. A scour pool and riffle are present immediately downstream of the sluice at Seven Hatches. Downstream of the railway crossing there is a more varied section of alternating pools and riffles.

Sediment regime

For the purposes of Fluvial Audit the site was divided into four reaches. The first reach, upstream of Seven Hatches, is impounded and deposition of silt was observed on the channel bed. Silt is being trapped at the channel margins by emergent vegetation forming semi-permanent deposits at the bank toe. Poaching along the channel banks and localised toe scour is also sourcing fine sediment to the channel.

Downstream of Seven Hatches the dominant sediment process remains deposition of silt on the channel bed. Toe undermining is also occurring along the right hand bank downstream of cross-section MS03 which, combined with cattle poaching, is sourcing fine sediment to the channel. Flow is impounded upstream of the apron of the railway crossing.

The pool-riffle reach downstream of the railway crossing is geomorphologically active and exhibits cliff erosion and deposition of gravels as discrete point bar deposits. This reach terminates at a widened section where two field drains join the main channel sourcing fine sediment to the channel.

Further downstream the channel reverts to a uniform glide which is impounded by the tractor bridge at the downstream boundary of the site. Toe scour and undermining is occurring along the outside of a meander on the right hand bank. The dominant sediment process is deposition on the channel bed.

Physical channel form

Levelling survey was conducted at eight cross-sections, the location of which is illustrated in **Maps 3.4a and 3.4b**. **Table 3.16** provides summary data for each of the cross-sections surveyed.

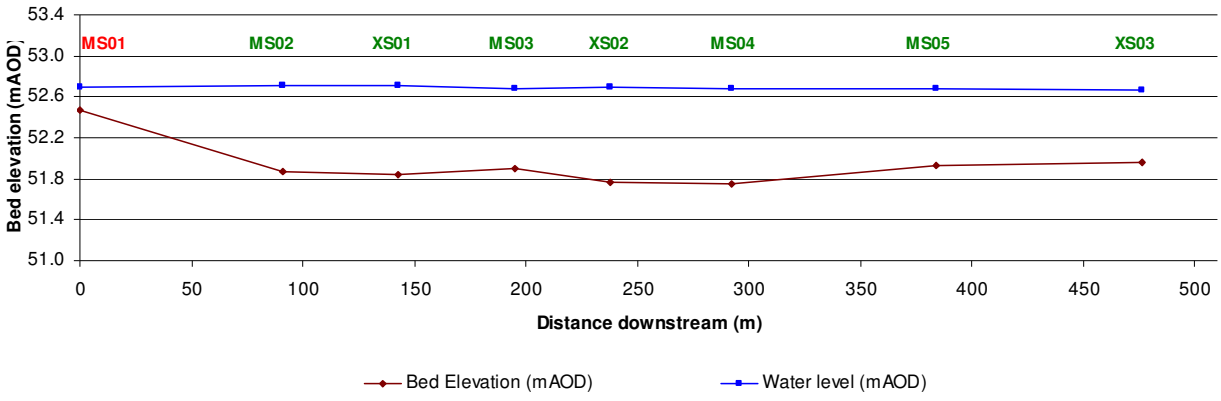
Table 3.16 Cross-sectional summary data

Transect	Physical biotope	Bankfull width (m)	Bankfull depth (m)	Width:depth ratio	Water width (m)	Water depth (m)
MS01	Riffle	17.06	1.88	9.1	10.08	0.23
MS02	Glide	14.75	1.76	8.4	8.47	0.84
XS01	Glide	12.36	1.64	7.5	8.64	0.87
MS03	Glide	13.51	1.83	7.4	9.86	0.78
XS02	Glide	16.46	1.98	8.3	8.35	0.93
MS04	Glide	16.00	1.90	8.4	9.13	0.94
MS05	Glide	16.51	1.81	9.1	10.22	0.74
XS03	Glide	13.57	1.34	10.1	10.41	0.71
Mean		**15.03**	**1.77**	**8.5**	**9.39**	**0.76**

The values presented in **Table 3.16** illustrate the uniformity of the channel's cross-sectional profile within the surveyed reach. The water depth is shallower at cross-section MS01, located within the riffle downstream of Seven Hatches. However, even within this section, the bankfull dimensions of the channel are comparable with cross-sections measured within the glide downstream. Throughout the reach the channel has been historically dredged (as evidenced by the presence of dredged material along the left hand bank), which is reflected in the low width:depth ratio throughout the reach. Spoil from dredging has been deposited along on the left hand bank forming an informal embankment.

The long profile of the channel, derived using the deepest points at each of the cross-sections, is presented in **Figure 3.7**.

Figure 3.7 Long profile



Over a distance of 476m (between cross-section MS01 and XS03), there is a fall in bed elevation of 0.51m (a gradient of 0.001). The long profile also illustrates the depth of the channel between cross-sections MS02 and XS03 in comparison with the "riffle" section at the upstream of the site (MS01).

Boundary conditions

The channel banks are graded and embanked with dredged material along the left hand bank. The right hand bank is graded upstream of the first meander. Further downstream the bank is poached and, in other locations, subject to toe scour and undermining which has produced a cliffed / undercut bank profile (see **Maps 3.4a and 3.4b**). Water vole burrows are evident along the bank at MS04. The banks are composed of sand/silt material with gravel within the matrix. Immediately downstream of Seven Hatches both banks are protected by artificial walling.

Bed substrate samples taken from the channel centre, both channel margins and intervening points (see **Table 3.17**) indicate that the dominant substrate within the centre of the channel is gravel material (2-16mm in diameter). This is overlain by silt throughout the reach and silt is the dominant substrate at the channel margins. Larger pebble substrate is dominant only within the riffle section at the upstream end of the reach.

Table 3.17 Bed substrate sampled at surveyed cross-sections*

Transect	Physical biotope	Right channel margin	Right of channel centre	Channel centre	Left of channel centre	Left channel margin
MS01	Riffle	Gravel / **Pebble**	Gravel / **Pebble**	Gravel / **Pebble**	Gravel / **Pebble**	Gravel / **Pebble**
		0.09	0.10	0.12	0.1	0.00
MS02	Glide	Silt	Silt	**Gravel** / Pebble	**Gravel** / Pebble	Silt
		0.00	0.01	0.01	0.01	0.00
XS01	Glide	Silt	Silt	**Gravel** / Pebble	**Gravel** / Pebble	Silt
		0.00	0.01	0.00	0.00	0.00
MS03	Glide	Silt	Silt	**Gravel** / Pebble	**Gravel** / Pebble	Silt
		0.00	0.01	0.00	0.00	0.00
XS02	Glide	Silt	**Gravel** / Pebble	**Gravel** / Pebble	**Gravel** / Pebble	Silt
		0.00	0.00	0.01	0.00	0.00
MS04	Glide	Silt	**Gravel** / Pebble	**Gravel** / Pebble	Silt	Silt
		0.00	0.01	0.00	0.00	0.00
MS05	Glide	Silt	**Gravel** / Pebble	**Gravel** / Pebble	**Gravel** / Pebble	Silt
		0.00	0.01	0.00	0.00	0.00
XS03	Glide	Silt	**Gravel** / Pebble	**Gravel** / Pebble	Silt	Silt
		0.00	0.01	0.00	0.00	0.00

*Left and right channel margins are defined looking in a downstream direction

****Bold type** indicates whether pebble or gravel sized substrate was dominant.

Velocity

Flow velocity measurement data is contained within **Appendix D** and summarised for each cross-section in **Table 3.18**.

Table 3.18 Velocity summary data

Transect	Physical biotope	Cross-sectional area of flow (m^2)	Mean Velocity (ms^{-1})
MS01	Riffle	1.72	0.103
MS02	Glide	4.74	0.010
XS01	Glide	5.47	0.010
MS03	Glide	5.64	0.010
XS02	Glide	4.66	0.010
MS04	Glide	5.88	0.010
MS05	Glide	5.82	0.010
XS03	Glide	5.36	0.010
Mean		**4.91**	**0.022**

The values presented in **Table 3.18** illustrates the uniformly low flow velocities occurring throughout the glide section of the reach in comparison with the upstream riffle section (MS01). The overwide/overdeep cross-sectional profile of the channel results in a larger cross-sectional area of flow which, combined with the influence of the railway crossing apron downstream, creates impounded slow flow conditions.

3.4.2 Biological characteristics

Vegetation structure

In-channel vegetation is limited to the pool-riffle section downstream of the railway crossing. Species present within this reach include brook water-crowfoot (*Ranunuclus pencillatus spp. pseudofluitans*) and duckweed (*Lemna minor)*.

Emergent vegetation is extensive throughout the site forming a marginal fringe which acts to trap fine sediment. The dominant species are reed sweet grass (*Glyceria maxima*) and branched bur-reed (*Sparganium erectum*), with localised greater pond sedge (*Carex riparia*). *Sparganium erectum* was also observed growing mid-channel, which is the first year this has been observed by the river keeper in seven years (Simmons, pers comm. 2006). The river keeper believes this to be due to low flows over the past two years.

The riparian zone within the site upstream of the railway crossing is narrow, indefinite or non-existent with cattle grazing up to the banktop. Non-native crop poplars (*Populus nigra*) have been planted at regular intervals, set back approximately 5m from channel along the left hand embankment. Shading of the channel occurs as a result of this for part of the day. Downstream of the railway crossing, riparian vegetation is more varied, including trees, shrubs and tall herbs. Bank erosion is also impinging on the fence line in one location where there is no riparian buffer zone. Further downstream, the riparian zone is continuous and comprised of tall herbs and ruderal vegetation with occasional clumps of trees.

Landuse within the site is predominantly semi-improved grassland on both banks. Downstream of the railway crossing landuse on the left hand bank is broadleaved woodland giving way to tall herb / ruderal vegetation in the final section.

Macrophyte coverage

A total of 70 taxa were recorded during the macrophyte assessment of the reach between Seven Hatches and the railway crossing. The locations of the 5 transects surveyed (MS01-MS05) were selected to represent different physical biotopes (see **Maps 3.4a and 3.4b**). Each of the transects was also subject to cross-section levelling survey (see Section 3.4.1).

The species there were found to be most common within the site, with a coverage of <5 % or more, are listed in **Table 3.19.** The site contains only one negative indicator species and no invasive species. However, the coverage of in-channel vegetation, including brook water-crowfoot (*Ranunuclus pencillatus spp. pseudofluitans*), is limited within the reach.

Glyceria maxima is the dominant emergent species and is extensive (>33%) along both channel margins. Cattle accessing the channel have poached the banks, destabilising the banks and promoting the formation of berm-like features at the base of the bank. These berms have helped to create a transitional zone for emergent species along the right hand bank.

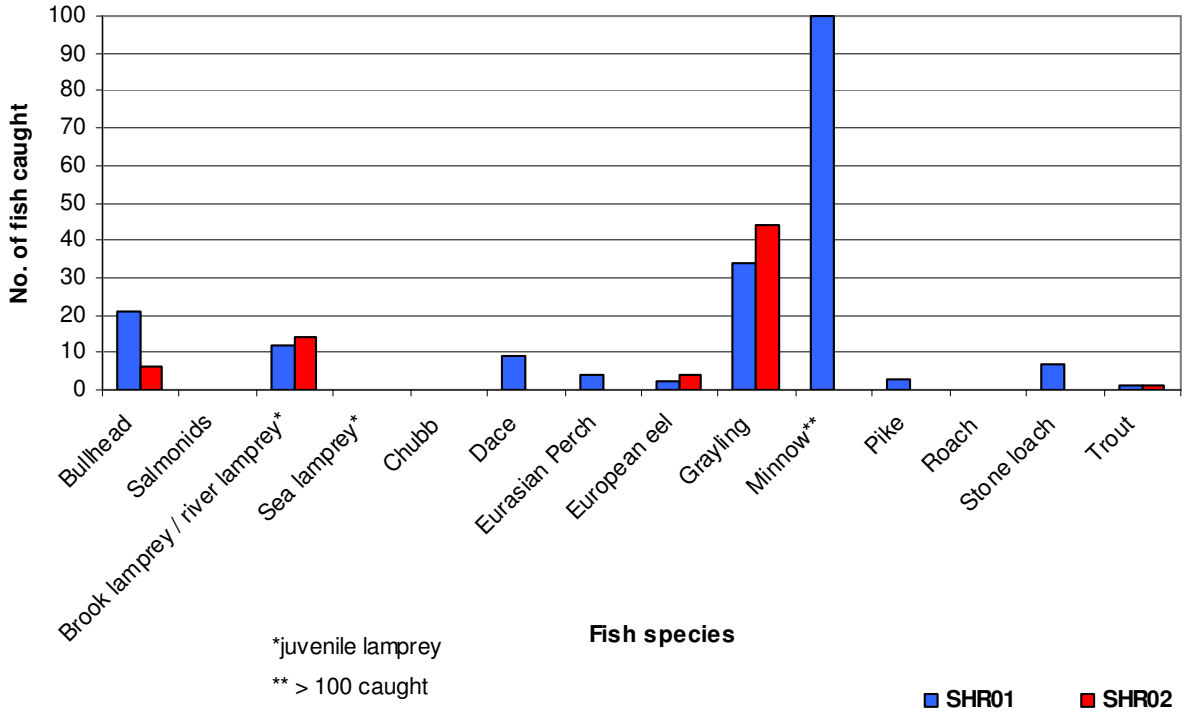
Table 3.19 Macrophyte species coverage (%) within site SHR

Latin Name	Common Name	Macrophyte coverage (%)					
		MS01	MS02	MS03	MS04	MS05	Whole site
		Run	Glide	Glide	Run	Glide	
Key species							
Ranunculus penicillatus spp. pseudofluitans	brook water-crowfoot	<1			<5		<5
Oenanthe crocata	hemlock water dropwort						<5
Species present in <5 %							
Glyceria maxima	reed sweet grass		10	<5	<1	<5	10
Agrostis canina	velvet bent						<5
Apium nodiflorum	fool's watercress						<5
Carex hirta	hairy sedge		<1	<1	<1	<1	<5
Carex riparia	greater pond sedge		<1				<5
Juncus inflexus	hard rush			<1		<1	<5
Lolium perenne	perennial ryegrass						<5
Mimulus guttatus	monkey flower						<5
Myosotis scorpioides	water forget-me-not	<1	<5	<5	<5	<5	<5
Agrostis canina	velvet bent						<5
Ranunuclus repens	creeping buttercup	<5	<5	10	<1	<5	<5
Rumex sanguineus	wood dock		<1		<1	<1	<5
Sparganium erectum	branched bur-reed	<1	10	<5	<5	<1	<5
Urtica dioica	common nettle	10	<1	<1			<5
Negative indicators							
Potamogeton pectinatus	fennel pondweed						<1
Invasive species							
None							
No of Taxa Recorded		**14**	**20**	**19**	**22**	**13**	**70**

Fisheries survey

Electro-fishing was undertaken at two sites, the location of which is indicated in **Maps 3.4a and 3.4b.** The total number of each fish species caught at each site during the electrofishing survey, including the Annex II species for which the Avon SAC is designated, is indicated in **Figure 3.8**.

Figure 3.8 Number of fish caught during electrofishing of sites SHR01 and SHR02



The calculated minimum density of brook lamprey and bullhead within both of the meso-habitats surveyed is shown in **Table 3.20**.

Table 3.20 Minimum density of brook lamprey and bullhead per m^2.

Fish species		Brook lamprey (quadrats only)		Brook lamprey (quadrat & sweep)		Bullhead	
Meso-habitat		**SHR01 (Glide)**	**SHR02 (Glide)**	**SHR01 (Glide)**	**SHR02 (Glide)**	**SHR01 (Glide)**	**SHR02 (Glide)**
Area		**5**	**5**	**24**	**24**	**1200**	**1200**
No. fish caught	**Shock 1**	2	1	2	1	9	3
	Shock 2	2	5	2	5	12	3
	Shock 3	2	2	2	2		
	Total	6	8	6	8	21	6
Minimum density (observed no. per m^2)		**1.20**	**1.60**	**0.25**	**0.33**	**0.018**	**0.005**

Table 3.20 indicates that the observed minimum density of bullhead is greatest within meso-habitat SHR01. **Figure X** also indicates that a greater range of other fish species

caught within meso-habitat SHC01. This may indicate preference of these species for the less impounded flow conditions found within meso-habitat SHR01 in comparison with SHR02.

The observed minimum density of brook lamprey caught within the quadrat survey and the total number of brook lamprey caught (**Table 3.20**) are similar for both meso-habitats. This may reflect the fact that silted margins are found within both meso-habitats.

3.4.3 Physical and biological relationships

- Due to historical dredging the cross-sectional profile of the channel in this reach is uniform, overwide and overdeep.
- The channel form combined with impoundment upstream of the railway crossing results in low flow velocities and siltation on the channel bed.
- The physical condition of the channel is currently limiting the extent and diversity of in-channel vegetation.
- Macrophyte growth is dominated by emergent species growing along the channel margins and in-channel. These species are able to establish in silt on the channel bed under slow flow conditions. Coverage of brook water-crowfoot is extremely limited and is likely to be inhibited by slow flow conditions and high water depth.
- The observed minimum density of bullhead and number of other fish species caught is greatest within the upstream glide meso-habitat. This may reflect a preference for less impounded conditions within this meso-habitat.

4 RAPID ASSESSMENT RESULTS

4.1 Fovant

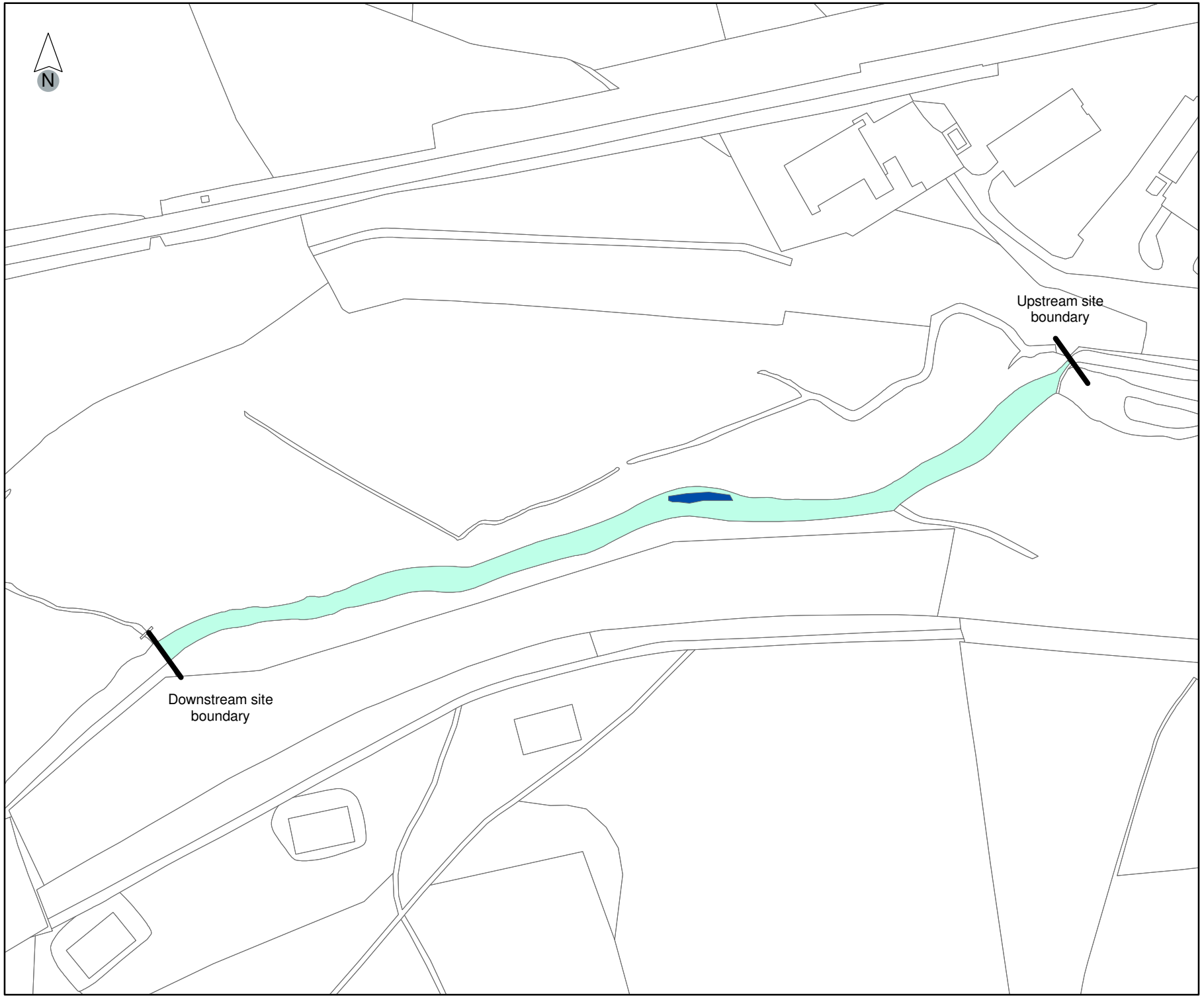
Upstream limit: 400215 139594
Downstream limit: 400672 130740
Length of site: 490m

Location:
This site is located on the River Nadder near Dinton, upstream of a sluice structure (**Map 4.1**). The upstream boundary of the site is located where a drain flowing from Mill Farm joins the main channel. The downstream boundary of the site is the iron hatches structure itself (**Figure X**).

Typical photographs:

Photo FOR01h:
Looking upstream along the glide physical biotope with broadleaved woodland along the right hand bank.

Photo FOR01s:
Looking across downstream towards iron hatches structure at the downstream site buondary.



Legend

Physical biotope

Glide

Pool

Title:
Fovant Restoration Site (FOR)
Location and physical biotopes

Project:
Avon STREAM Monitoring Project

Client:
Natural England

Date:
28/11/2006

Scale:
1:2,500

Map 4.1

ROYAL HASKONING

4.1.1 Physical Characteristics

Physical biotopes
Flow is impounded along the length of the site therefore the main physical biotope present is a ponded glide. There is also a pool within the central section of the site (**Map 4.1**).

Sediment regime
Despite the ponded flow conditions, evidence of channel adjustment through erosion was observed during the Fluvial Audit (see **Appendix A**). Localised toe scour is occurring on the left hand bank around the outside of two gentle meander bends. At the second meander bend this is associated with a pool. Bank reinforcement and willow planting has been installed to limit bank erosion. The right hand bank is consolidated by tree roots from continual treelining upstream of the confluence with the field drain on the right hand bank.

The predominant sediment process within the site is deposition of fine sediment on the channel bed. This is occurring in response to impounded flow conditions and previous modifications to the channel which have increased its width and depth.

4.1.2 Biological characteristics

In-channel vegetation occurs intermittently along the channel and is limited in diversity to stands of unbranched bur-reed (*Sparganium emersum*).

Emergent vegetation is present along the left hand bank. The dominant species are reed sweet grass (*Glyceria maxima*) and greater pond sedge (*Carex riparia*). Water mint (*Mentha aquatica*) is present at limited locations where a transitional zone exists between the channel and bank. Towards the upstream end of the site such a zone has been created through the installation of a marginal shelf of brushwood and wire by the local angling club. Towards the downstream end of the site a transitional zone exists as a result of the shallower channel banks. Emergent and marginal vegetation along the right hand bank is limited by shading which results from the adjacent broadleaved woodland landuse.

The riparian zone along the right hand bank is better established than along the left hand bank but is dominated by common nettle (*Urtica dioica*). Along the left hand bank there is a mown grass fisherman's path which limits the width of the riparian zone. Species present include silverweed (*Potentilla anserine*), common fleabane (*Pulicaria dysenterica*). Himalayan balsam (Impatiens glanifer), an invasive non-native species is also present is two locations along the left hand bank.

Landuse along the left hand bank is a historic water meadow and is now unimproved grassland / extensive grazing. The ditch system within this field contains greater pond sedge (*Carex riparia*), reed sweet grass (*Glyceria maxima*) and reed-canary grass (*Phalaris arundinacea*). Evidence of water voles was also observed along the left hand bank.

4.1.3 Summary of physical and biological relationships

- The cross-sectional profile of the channel is overwide and overdeep as a result of historical channel modification through dredging. This, combined with impoundment upstream of the iron hatches, results in deep, slow flow conditions.

- The depth and flow conditions within the channel are currently limiting the extent and diversity of macrophyte species within the channel.

- The lack of a hydrological transition zone between the channel and the banks is restricting the coverage of marginal fringe species such as water mint (*Mentha aquatica*).

- Shading along the right hand bank is limiting the diversity of riparian and emergent macrophyte species along this bank.

4.2 Amesbury

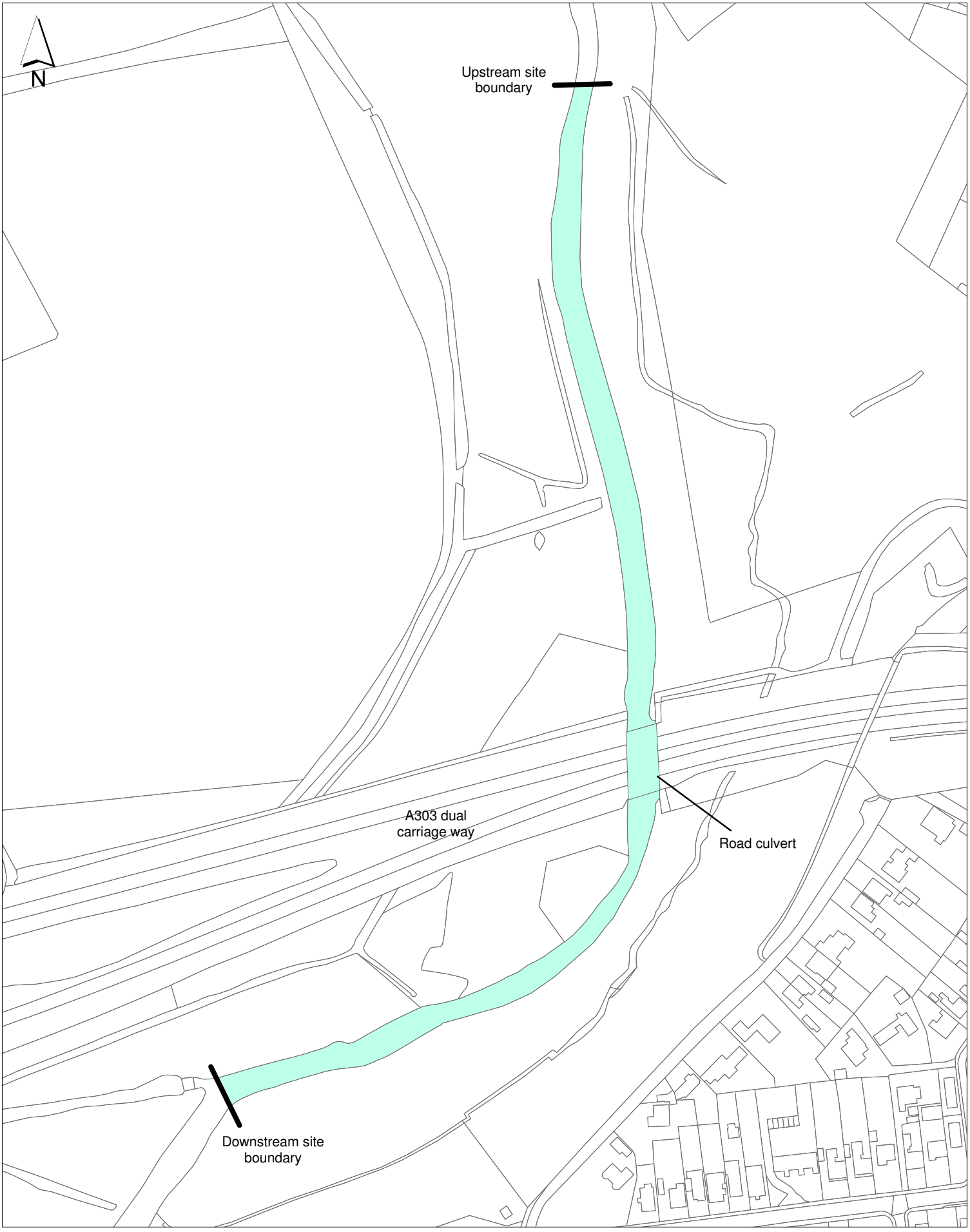
Upstream limit: 415044 142522
Downstream limit: 415655 142005
Length of site: 654m

Location:
The site is located either side of the A303 dual carriage way to the north of Amesbury. The upstream boundary of the site is parallel to the beginning of the ditch system on the left hand bank. The downstream boundary of the site is where the river branches in two, upstream of a weir structure. The A303 crosses at approximately the mid-point of the site.

Typical photographs:

Photo AMR01j:
Looking upstream along the glide physical biotope upstream of the road crossing. The fisherman's path is along the left hand bank.

Photo AMR02e:
Looking downstream along glide physical biotope downstream of the road crossing. The public footpath is along the left hand bank.



Legend

Physical biotope

Glide (laminar)

Title: Amersbury Restoration Site (AMR)
Location and physical biotopes

Project: Avon STREAM Monitoring Project

Client: Natural England

Date: 27/11/2006

Scale: 1:2,500

Map 4.2

ROYAL HASKONING

4.2.1 Physical Characteristics

Physical biotopes
The site consists of a glide which is divided in two by the culvert under the A303 dual carriage way (**Map 4.2**). The bed of the culvert is artificial and is acting as a grade control between the two sections.

Sediment regime
The Fluvial Audit recorded no evidence of natural channel adjustment through erosion (see **Appendix A**). Localised sourcing of fine sediment to the channel is occurring due to poaching by humans and dogs within the land open to public access.

The predominant sediment process within the site is deposition of fine sediment on the channel bed and at the channel margins. This is occurring in response to the overwide / overdeep nature of the modified channel and consequently slow flow conditions.

4.2.2 Biological characteristics

In-channel vegetation occurs throughout the channel but is limited to unbranched bur-reed (*Sparganium emersum*), duckweed (*Lemna minor*) and the negative indicator fennel pondweed (*Potamogeton pectinatus*).

Emergent vegetation is present semi-continuously along the right hand bank. The dominant species are branched bur-reed (Sparganium erectum) and (*Glyceria maxima*), with greater pond sedge (*Carex riparia*) occurring in the downstream section of the site. Small stands of emergent vegetation occur intermittently along the left hand bank and include yellow flag (*Iris pseudacorus*). Due to the modified nature of the channel there is lack of transitional zone between the channel and bank.

The riparian zone along the right hand bank is better established than along the left hand bank but is dominated by ruderal vegetation such as common nettle (*Urtica dioica*), with great willow herb (*Epilobium hirsutum*) occurring downstream of the road culvert. Along the left hand bank there is a mown grass fisherman's path which limits the width of the riparian zone. Species present include common nettle (*Urtica dioica*) and great willow herb (*Epilobium hirsutum*).

Landuse along the right hand bank consists of a black poplar plantation set back from the channel bank. The downstream section of the site is open to public access and a footpath follows the right bank. On the left hand bank the landuse is tall ruderal vegetation dominated by common nettle (*Urtica dioica*).

4.2.3 Physical and biological relationships

- The cross-sectional profile of the channel has been widened and deepened as a result of historical dredging. This, combined with impoundment upstream of the downstream weir, results in deep, slow flow conditions.

- The depth and flow conditions within the channel are currently limiting the extent and diversity of macrophyte species within the channel.

- The lack of a hydrological transition zone between the channel and the banks is restricting the coverage of marginal fringe species such as water mint (*Mentha aquatica*).

- The width of the riparian zone is restricted along the left hand bank due to footpaths used for fishing and public access.

Appendix A: Reach-Scale Mapping

Appendix B: Photographic Records

Appendix C: Macrophyte Survey Data

Appendix D: Cross-sectional and DVS Survey Data

Appendix E: Fisheries Survey Data

Appendix F: Electronic Record of Survey