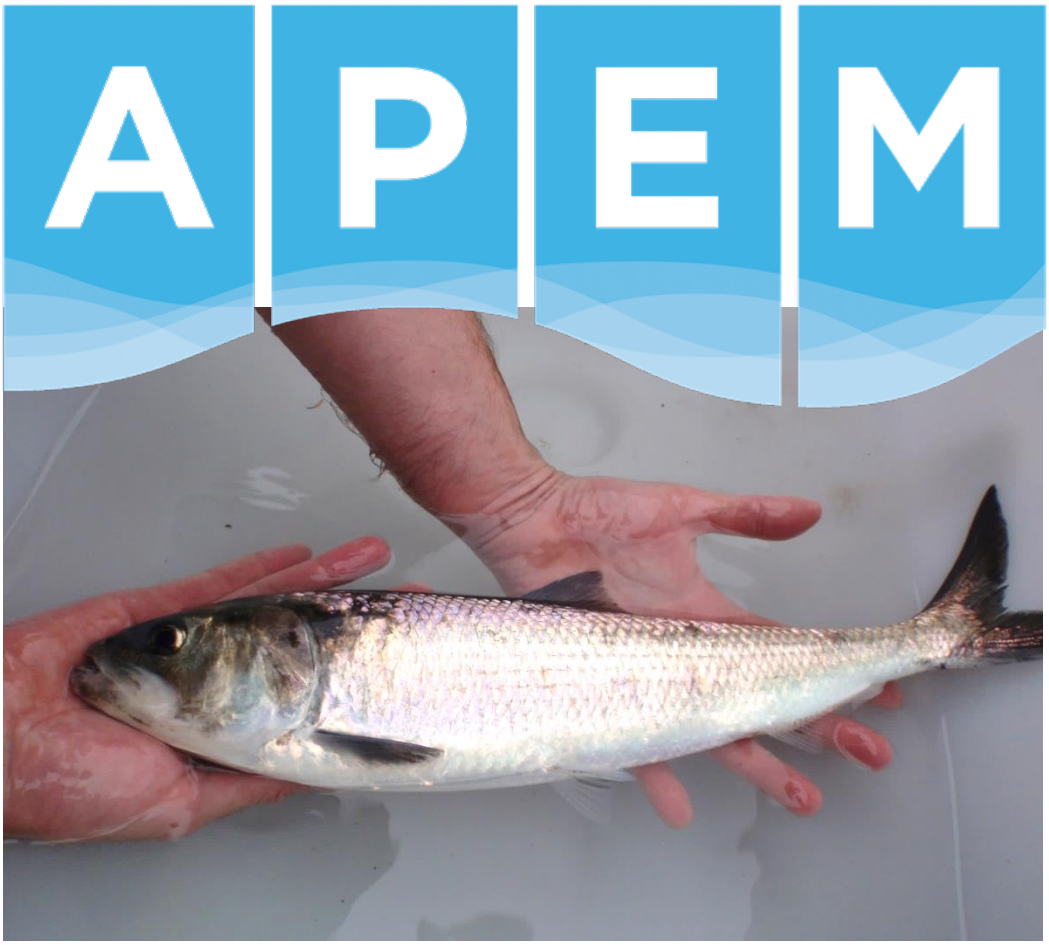

A habitat survey for spawning ground and nursery areas for Annex II fish species within the Severn Estuary river catchment

Client: Natural England

APEM Ref: 413588

January 2015

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Executive Summary

APEM Ltd was commissioned to undertake surveys to identify shad and lamprey habitat on the lower River Severn (downstream of Diglis Weir) and the lower River Teme (Downstream of Powick Weir). Suitable habitat was defined according to previously identified habitat criteria based on substrate type and hydraulic conditions, and survey was undertaken from a boat, combined with bankside surveys.

The results of the survey found that suitable shad and lamprey habitat were present in the River Teme, however almost no suitable habitat was identified in the lower River Severn. Subsequently, potential monitoring locations were identified within the River Teme, but it was not possible to identify specific monitoring sites in the Severn. Notwithstanding that no specific shad or lamprey habitat was identified within the River Severn, it may still prove an important habitat for these species due to its large spatial extent. Therefore sampling strategies for the River Severn are discussed, but due to the lack of species specific habitat and the likely low densities of fish, high intensity surveys for the species of interest are likely to be required.

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1. Introduction

The Severn Estuary Special Area of Conservation (SAC) and European Marine Site is designated for eight interest features including twaite shad (*Alosa fallax*), river (*Lampetra fluviatilis*) and sea (*Petromyzon marinus*) lamprey. Natural England has a statutory duty to assess the condition of each feature against conservation objectives. For diadromous fish species such as shad and lamprey, the most appropriate means of assessing the estuarine population is to use population estimates from the afferent rivers (in which the estuarine populations spawn) as a proxy for the estuarine population. The River Severn constitutes one of the major rivers of the Severn Estuary, and population data from the Severn is thus required to inform the overall status of shad and lamprey within the Severn Estuary SAC.

In order to undertake shad and lamprey population surveys in the Severn, it is necessary to identify suitable habitat for these species at which population sampling using JNCC common standards monitoring techniques can be deployed. To this end APEM was commissioned by Natural England to identify suitable spawning and nursery grounds for juvenile shad and lamprey. The area of interest for this study as defined by Natural England incorporates the rivers Severn (downstream of Diglis Weir [at NGR: SO 84639 53474] to Maisemore weir *ca*. 40km downstream [at NGR: SO 81807 21658]) and Teme (lower *ca*. 3km between Powick Weir [at NGR: SO 83190 52413] and the confluence with the Severn [at NGR: SO 85011 52204]).

An assessment of potential twaite shad and allis shad (*A. alosa*) spawning habitat on the Rivers Severn and Teme was previously undertaken by the Environment Agency in 2014 (Cowley, 2014). This method used aerial surveys and historic River Habitat Surveys (RHS) to assess large stretches of the rivers for habitat suitability upstream of Diglis and Powick Weirs on the Severn and Teme, respectively. Diglis and Powick weirs are thought to be largely impassable obstacles to upstream migrating shad and lamprey, and thus theoretically some of the habitat downstream of these sites must be suitable spawning and nursery habitat for these species due to their continuing presence in the watercourse. Therefore, additional habitat surveys of lower reaches of the two rivers for shad, were commissioned via the current study, in order to provide a complete picture of shad habitat availability. Given the opportunities that a shad habitat survey presented, identification of habitat for lamprey species was also included as a project objective.

This report outlines the methods and results of the shad and lamprey surveys undertaken in the area of interest during September 2014, to determine the presence and extent of suitable lamprey and shad spawning and nursery habitat.

1.1 Study aims and objectives

There are two main objectives of this project; a habitat survey and determination of potential monitoring locations within the survey region. The aims of each of these objectives are outlined in the following sub-sections.

1.1.1 Objective 1: Habitat survey

Aim is to undertake a habitat survey to:

a) Identify and quantify potential areas for spawning adult shad and lamprey species; and
b) Identify and quantify potential nursery areas for larval and juvenile shad, and lamprey ammocoetes.

1.1.2 Objective 2: monitoring locations

Aim to identify the most suitable locations for an initial feasibility study for monitoring:

- Egg production of adult shad;
- Numbers of juvenile shad; and
- Numbers of lamprey ammocoetes.

2. Methods

2.1 Habitat survey

The habitat survey technique used was based around the Environment Agency's Fisheries Technical Manual 4: Restoration of Riverine Salmon Habitats (Hendry & Cragg-Hine, 1997), devised by APEM. To enable mapping of both river banks and the mid-channel habitat, the survey was undertaken by making direct observations from a boat within the river channel.

Various habitat types were recorded by hand annotating high resolution (1:1000) Ordnance Survey 1km base maps. For the purposes of this survey, flow type, depth and substrate type were all recorded in the field, according to standard RHS definitions. Exact criteria for defining shad and lamprey habitat are detailed in **Table 2.1** and **Table 2.2**, respectively.

Table 2.1. Definitions of habitat types for relevant life stages of shad.

Life Stage	Habitat definition		Reference
	APEM survey method	RHS based study by Cowley (2014)	
Twaite shad spawning	Depth below 1m High flow velocity – Riffle or Run habitat Cobble or gravel substrate	Unbroken standing wave or rippled flow Cobble, gravel and pebble	Caswell & Aprahamian (2001)
Twaite shad larvae	Marginal dead water Low velocity Pools / areas of pools In close proximity to spawning habitat	Pools and slow moving water recorded as marginal deadwater, no perceptible flow, smooth flow	Caswell & Aprahamian (2001)
Twaite shad juveniles	Marginal dead water Low velocity Pools / areas of pools In close proximity to spawning habitat	Pools and slow moving water recorded as marginal deadwater, no perceptible flow, smooth flow	APEM experience gained via shad juvenile sampling (e.g. APEM, 2010)

Table 2.2. Definitions of habitat types for relevant life stages of sea and river lamprey.

Species / Life Stage	Habitat definition	Reference
Lampetra spawning	Areas of small stones and gravel in flowing water	Maitland (2003).
Petromyzon spawning	Flowing shallow water amid gravel	
Lampetra ammocoetes	Stable fine sediment or sand > 15 cm deep, low water velocity and the presence of organic detritus	APEM (2002) Harvey & Cowx (2003)
Petromyzon ammocoetes	Non-marginal (open channel) sites of >1.5m depth featuring fine sand and silt accumulations; lower velocity areas of pools and glide habitat	Teague *et al*. (2014)

Petromyzon (sea lamprey) ammocoete habitat is located in relatively deep water (**Table 2.2**) and thus generally not visible. Therefore, where the flow conditions were as described in **Table 2.2** for petromyzon ammocoetes, the presence of suitable sand / silt sediment was determined by using APEM's lamprey airlifting technique (see **Appendix I**) or grab samples, with results recorded and subsequently mapped. The definitions used to describe various habitats on the maps are provided in **Table 2.3**.

Table 2.3. Definitions of ecologically functional habitat types used on the output maps.

Species / Life Stage	Habitat definition
Juvenile lamprey	Suitable lamprey substrate located within the channel margins, with no specific features present for shad (i.e. pools / backwaters)
Combined juvenile shad / lamprey	Suitable lamprey substrate and pools / backwaters
No ecological habitat	Habitat has no distinct features associated with either lamprey or shad habitat.
Juvenile shad habitat	Pools / backwaters present, but substrate not suitable for lamprey.
Deep spawning (lamprey & shad)	Suitable shad / lamprey spawning habitat between 0.4m and 1m deep.
Lamprey only spawning	Suitable shad / lamprey spawning habitat but at water depths <0.15m (Note: this may still be suitable habitat for shad during the spawning period if depths are greater).
Shallow spawning (lamprey & shad)	Suitable shad / lamprey spawning habitat between 0.15m and 0.4m deep.

On return to the laboratory, the hand annotated maps were digitised into GIS format. The GIS output is provided as a separate deliverable under this project, and map outputs from the GIS are provided in **Appendices II** and **III** for the Rivers Teme and Severn respectively.

2.2 Monitoring locations

Site selection for an initial feasibility study was based primarily on habitat suitability for each species / life stage as determined by the findings of the habitat survey. Consideration was also given to the logistical practicality of surveying at each proposed monitoring location, thus bankside and in-channel accessibility, likely survey efficiency, and health and safety of surveyors undertaking the survey were all taken into account. A justification for each site is provided in this report, together with details of specific access points and practical considerations which the ultimate survey team will need to know.

3. Habitat Survey Results

The habitat surveys were undertaken during September 2014 when flow conditions were moderate to low, with dry prevailing weather conditions.

3.1 Habitat survey

3.1.1 River Severn

All of the surveyed River Severn comprised relatively homogenous slow flowing deep glide habitat, with no distinct spawning or juvenile shad or lamprey habitat features present. Due to the uniform nature of the habitat, habitat survey maps provide little additional information, and due to their extent have not been provided as an appendix to this report.

Of 82 substrate samples taken 50 (61%) contained apparently suitable substrate for juvenile lamprey to reside (i.e. un-compacted silt and / or fine sand substrate), although no lamprey ammocoetes were captured in any samples during the survey. 18 (22%) of the samples had at least a trace of gravel, pebble or cobble substrate which may be suitable shad spawning substrate, although 13 of these samples were taken mid-channel, where depths were likely in excess of the 1m limit described for shad, and the flows associated with all 18 sites were deemed unsuitable (e.g. no glide or riffle flow).

3.1.2 River Teme

Maps of the River Teme survey results showing the locations of ecologically functional habitats and flow types are provided in **Appendix II**. Analysis of the habitat walkover survey found that the majority (83%) of the channel flow was glide (**Figure 3.1**), with a total of 94% of the flow conditions being suitable for shad spawning (i.e. run, riffle, and glide). When considering substrate composition and flow characteristics for shad spawning habitat, approximately 6% of the habitat was suitable for shad spawning (**Figure 3.2**).

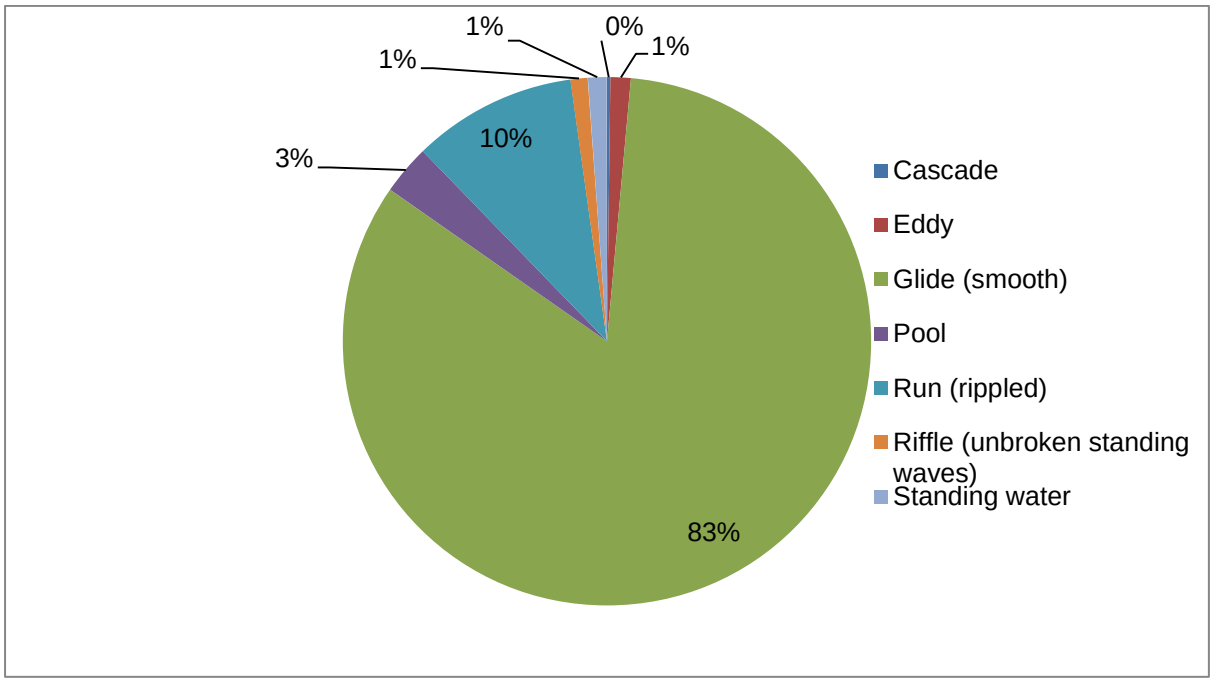


Figure 3.1. Percentage area of surveyed River Teme comprising various flow types.

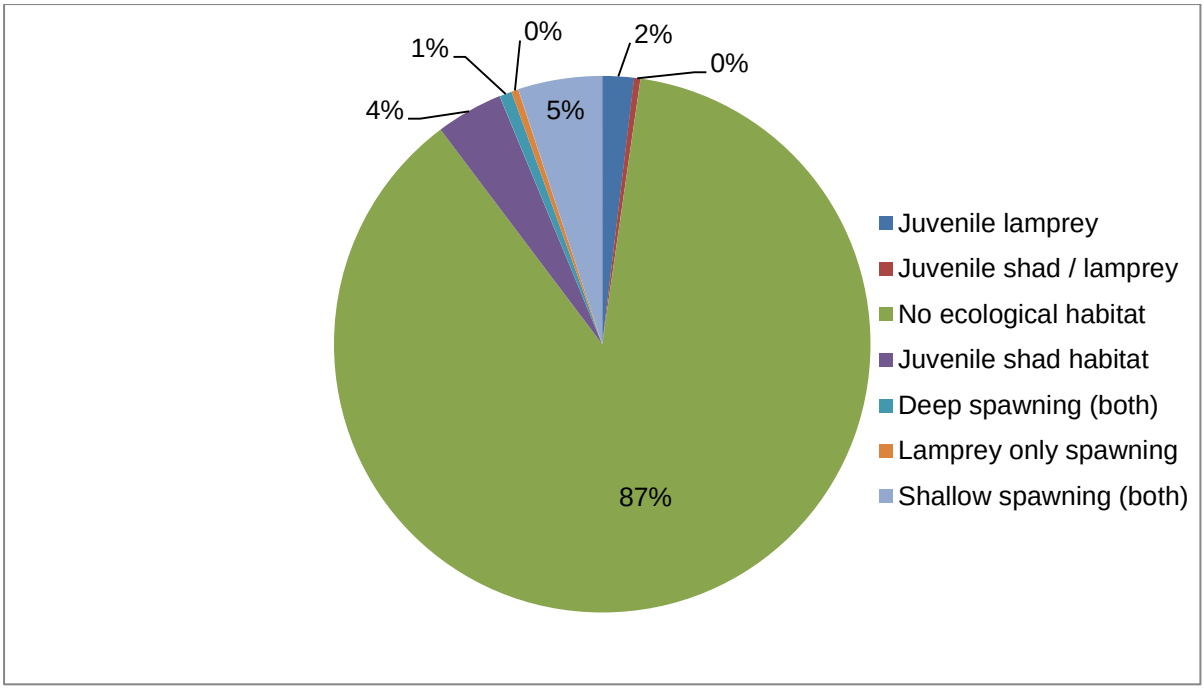


Figure 3.2. Percentage area of surveyed River Teme comprising various ecologically functional habitats (accounting for flow and substrate type) for lamprey and / or shad.

Table 3.1. Habitat composition in the surveyed River Teme (accounting for flow and substrate type) for lamprey and / or shad.

Functional habitat	Area (m^2)	Percentage of total area (%)
Juvenile lamprey	1,742	2
Juvenile shad / lamprey	354	0
No ecological habitat	80,432	87
Juvenile shad habitat	3,711	4
Deep spawning (both)	682	1
Lamprey only spawning	389	0
Shallow spawning (both)	4,667	5
Total	**91,977**	**100**

Ecologically functional juvenile lamprey habitat in the surveyed River Teme comprised *ca*. 2% of the total area, whereas *ca*. 4% of the surveyed reach was deemed suitable juvenile shad habitat.

Based on the parameters outlined in **Section 2**, 6% of the surveyed River Teme was deemed suitable spawning habitat for both lamprey and shad, with an additional <0.5% of the area being suitable for lamprey species only.

The various suitable shad spawning and juvenile habitat types were generally interspersed, e.g. high water velocity riffle spawning habitat was in close proximity to low velocity pools suitable for juveniles.

3.2 Monitoring locations

The homogenous nature of the surveyed reach of the River Severn meant that no specific lamprey or shad habitat features were observed during the survey and thus it was not possible to identify any one location as being more suitable for lamprey or shad population monitoring than any other location.

The surveyed stretch of the River Teme comprised a number of areas of suitable shad and lamprey spawning and juvenile habitat. Recommended monitoring sites on the River Teme are provided in **Table 3.2** to **Table 3.4**, which are broken down into potential shad spawning, juvenile shad, and juvenile lamprey survey locations. The proposed survey locations are circled on the maps provided in **Appendix II**, with red circles representing shad spawning sites, blue circles shad juvenile sites, and green circles juvenile lamprey sites.

Table 3.2. Proposed sites for monitoring shad spawning via presence of eggs on the River Teme (ordered upstream to downstream).

Site NGR	Habitat type	Justification
SO 83254 52363	Shallow spawning	First spawning habitat identified downstream of Powick Weir. Access is located on the right hand bank.
SO 83521 52471	Shallow spawning	Spawning location in close proximity to pools for adults to hold prior to spawning. Easy access possible from both banks.
Ca. 100m stretch from SO 83650 52375 to SO 83733 52340	Mixed shallow and deep spawning	Significantly large stretch of suitable habitat spanning entire channel width. Access possible from both banks, but left hand bank likely to be the most appropriate.
SO83916 52382	Shallow spawning	*Ca*. 25m long stretch of suitable habitat, spanning entire channel width. Access possible from both banks.
SO 84634 51823	Shallow spawning	*Ca*. 25m long stretch of suitable habitat, spanning entire channel width. Most downstream area of suitable habitat identified before confluence with the River Severn. Access possible from both banks.

Table 3.3. Proposed sites for monitoring juvenile shad on the River Teme (ordered upstream to downstream).

Site NGR	Habitat type	Justification
SO 83206 52378	Juvenile shad	Located immediately downstream of Powick Weir. Access is located on the right hand bank.
SO 83521 52471	Juvenile shad	Easy access possible from both banks. Relatively large area of suitable habitat.
SO 83776 52336	Juvenile shad	*Ca*. 25m long pool spanning entire channel width. Access from both banks possible, but right hand bank appears steep with collapsed walls, therefore access via left hand bank recommended.
SO 83995 52355	Juvenile shad	*Ca*. 25m long stretch of suitable habitat on the left hand bank of the river within an eddy. Access possible for left hand bank.
SO 84171 52409	Juvenile shad	*Ca*. 25m long stretch of suitable habitat on the left hand bank of the river within pool. Access possible for left hand bank.
SO 84637 51840	Juvenile shad	*Ca*. 25m long stretch of suitable habitat on the left hand bank of the river within pool. Downstream –most area of suitable habitat identified before confluence with the River Severn. Access possible for left hand bank.

Table 3.4. Proposed sites for monitoring juvenile lamprey on the River Teme (ordered upstream to downstream).

Site NGR	Habitat type	Justification
SO 83206 52378	Juvenile lamprey	Located immediately downstream of Powick Weir. Access is located on the right hand bank.
SO 83521 52471	Juvenile lamprey	Easy access possible from both banks. Relatively large area of suitable habitat.
SO 83776 52336	Juvenile lamprey	Lamprey habitat present on left hand bank, which is associated with easy access to the river.
SO 84035 52361	Juvenile lamprey	Lamprey habitat present on left hand bank, which is associated with easy access to the river.
SO 84035 52361	Juvenile lamprey	Lamprey habitat present on left hand bank, which is associated with easy access to the river.
SO 84149 52409	Juvenile lamprey	Lamprey habitat present on left hand bank, which is associated with easy access to the river.
SO 84637 51840	Juvenile lamprey	*Ca*. 25m long stretch of suitable habitat on the left hand bank of the river within pool. Most downstream area of suitable habitat identified before confluence with the River Severn. Access possible for left hand bank.

4. Discussion

Using the previously identified habitat feature descriptors, no shad specific habitat was identified in the surveyed main stem of the River Severn. The entire stretch comprised relatively slow flowing glide (**Appendix III**), which is one of the spawning habitat features of shad. Therefore, in theory the entire stretch may provide suitable shad spawning habitat, however the substrate was generally unsuitable at water depths less than 1m (required for shad spawning habitat – Caswell & Aprahamian, 2003) and no marginal deadwater or backwaters were observed for juvenile nursery habitat. Both Maitland & Hatton-Ellis (2003) and Caswell & Aprahamian (2001) observed that a diversity of habitat features within close proximity may be necessary to provide suitable habitat (e.g. a pool, riffle and glide series), which was not observed in the surveyed stretch of the River Severn. Aprahamian *et al*. (1998) noted that spawning gravels for shad were often associated with slow flowing pools where the adults could hold position during the day before spawning at night.

In addition to assessing the occurrence of potential shad habitat, APEM assessed the presence of lamprey habitat. As for shad, no specific areas of suitable lamprey habitat were identified in the surveyed River Severn. Sediment samples identified that suitable sediment physical properties (i.e. grain size) were deemed to be present for lamprey ammocoetes throughout the Severn (i.e. 61% of the sediment), however no lamprey were captured when sampling the River Severn using the airlifting or grab technique. This may be due to suitable lamprey spawning habitat potentially being only located much further upstream in the watercourse than the surveyed river reaches (i.e. adult lamprey can migrate beyond Diglis Weir to spawn), such that displacement of larvae and ammocoetes downstream is not sufficient to transport them to the survey locations. For example, Derosier *et al*. (2007) observed sea lamprey ammocoetes to disperse approximately 150m to 1000m during the first season after hatching. It is also important to note that sea lamprey ammocoetes may be present, but were not sampled due to only a relatively small proportion of the riverbed, at a limited number of point sample locations, being sampled using the airlifting technique. In addition, only the basic physical property of the sediment was assessed (e.g. silt, gravel, cobble), but potentially the chemical characteristics of the sediment may be unsuitable for ammocoetes to reside.

In comparison to the River Severn, the surveyed stretch of the River Teme had a number of habitat features suitable for lamprey and shad spawning and nursery habitat throughout the stretch (see **Appendix II**). It is possible that the surveyed stretch of the River Teme therefore, comprises an important spawning and nursery ground for both shad and lamprey species within the Severn catchment, particularly when considering the lack if identified habitat features within the Severn itself downstream of Diglis Weir. Therefore, monitoring of shad and lamprey in the River Teme is potentially of greater importance than within the stretch of the River Severn downstream of Diglis Weir. If the surveyed stretch of the River Teme is indeed the primary area of shad spawning for the Severn catchment, surveys would likely find a high concentration of spawning adults, eggs, and juveniles within this region, notwithstanding that juvenile shad may migrate into the main stem of the River Severn. A monitoring program for shad and lamprey in the Teme, which targets specific habitat features, is possible due to the findings of the current habitat survey and potential survey sites have been identified in **Section 3.2**. Such a survey program would verify the importance of the River Teme for shad and lamprey.

Notwithstanding that the River Severn downstream of Diglis Weir provides no specific habitat according to the defined habitat criteria employed in this document, the Severn may nonetheless be of some importance. Although Caswell & Aprahamian (2001) identified that the optimum habitat for shad in the their study sites was <1m depth of water, samples for shad eggs were not undertaken at depths greater than *ca*. 1.3m and thus the importance of

deeper habitat could not be ruled out. Samples undertaken in the Elbe estuary in Germany found shad spawned at depths of 8 to 9.5m, with the peak egg densities being at depths of more than 4m (Hass, 1968, and Thiel *et al*., 1996), further highlighting the potential that the deeper habitat in the River Severn may provide suitable spawning habitat for shad, although not within optimum conditions as identified previously. Caswell & Aprahamian (2001) also noted that shad eggs were always found in gravel/pebble substrate, irrespective of the dominant substrate in the area. Taking into consideration the findings of Caswell and Aprahamian, approximately 22% of the sediment samples taken during this study contained at least some gravel/pebble, although at depths greater than 1m, and thus only surveys to determine the presence or absence of shad eggs will provide definitive evidence as to whether the lower Severn is used for shad to spawn.

Although the habitat in the Severn may not be utilised by shad and lamprey to a great extent, it may nonetheless be of significant importance due to the large spatial extent of the river that may be utilised (i.e. a low extent of use, but which over the large area involved, becomes collectively significant). Determining the importance of the main stem of the River Severn as shad and lamprey habitat is likely to require an intensive and targeted population survey effort, rather than the current high level habitat assessment undertaken during this project. As no specific sites can be identified for monitoring to determine whether shad and / or lamprey do utilise the habitat, survey sites would either need to be randomised throughout the stretch of watercourse or set at regular intervals. However, the homogenous, and apparently sub-optimal nature of the shad and lamprey habitat in the Severn means that any survey program of sampling will have a high risk of not identifying any shad or lamprey spawning / residential locations unless a high number of samples are taken (i.e. to gain an understanding of what is likely to be a low density population a higher number of samples are required than for high density populations).

In light of the survey results for the current high level habitat assessment, it is recommended that targeted surveys for shad and lamprey are undertaken in the River Teme in the first instance. Surveys of the River Teme may determine whether there are significantly high numbers of fish utilising it, and in turn may indicate if it is likely to be the sole or predominant spawning site for shad and lamprey in the lower Severn catchment. A decision can subsequently be made on the value of undertaking fish surveys on the main stem of the Severn, which although unlikely to be of significant importance to shad and lamprey based on habitat characteristics, may nonetheless have some value.

5. References

APEM, 2010 Shad acoustic and entrainment study Phase 3. APEM Scientific Report 411031, 98pp.

APEM, 2002. Standardised sampling strategies and methodologies for condition assessment within SAC rivers for sea, river and brook lamprey and bullhead – Phase 2a Final Report. English Nature, Peterborough, 29 pp.

Aprahamian, M.W., Lester, S.M. & Aprahamian C.D., 1998. Shad conservation in England and Wales. Environment Agency Technical Report W110, 146pp.

Caswell, P.A. & Aprahamian, M.W., 2001. Use of River Habitat Survey to determine the Spawning habitat characteristics of Twait Shad (*Alosa fallax fallax*). *Bulletin Français de la Pêche et de la Pisciculture* **362/363**, 919-929.

Cowley, J., 2014. Assessment of potential shad spawning habitat on the Rivers Severn and Teme. Environment Agency report, September 2014, 15pp.

Derosier, A.L., Jones, M.L. & Scribner, K.T., 2007. Dispersal of sea lamprey larvae during early life: relevance for recruitment dynamics. *Environmental Biology of Fishes* **78**, 271-284

Harvey, J. & Cowx, I., 2003. monitoring the River; Brook and Sea Lamprey. Conserving Natura 2000 Rivers Monitoring Series No. 5. English Nature, Peterborough, 35pp.

Hass, H., 1968. Untersuchungen über die vertikale und horizontale Verteilung der eier der finte. *Alosa fallax* (Lacépède, 1803) in der Elbe. *Archiv für Fischereiwissenschaft* **19** 45-55. REFERENCED IN Aprahamian, M.W., Lester, S.M. & Aprahamian C.D., 1998. Shad conservation in England and Wales. Environment Agency Technical Report W110, 146pp.

Hendry, K. & Cragg-Hine, D., 1997. Fisheries Technical Manual 4: Restoration of Riverine Salmon Habitats. Environment Agency R & D Technical Report W44, 250pp.

Maitland, P.S. & Hatton-Ellis, T.W., 2003. Ecology of the Allis and Twaite Shad. Conserving Natura 2000 Ecology Series No. 3. English Nature, Peterborough, 32pp.

Maitland P.S., 2003. Ecology of the River, Brook and Sea Lamprey. Conserving Natura 2000 Rivers Ecology Series No. 5. English Nature, Peterborough, 54pp.

Teague, N.J., Williams, A.E., Clough, S.C., Teague, L. & Hendry, K., 2014. The use of deep water habitat by lamprey ammocoetes: Implications for Condition Assessments in SACs. *In prep*.

Thiel, R., Sepulveda, A. & Oesmann, S., 1996. Occurrence and distribution of twaite shad (*Alosa fallax* Lacépède) in the lower Elbe river, Germany. *In* Kirchhofer, A. & Hefti, D. (Eds.). Conservation of Endangered Freshwater Fish in Europe. Pp 157-170. Birkhäuser Verlag, Basel.

6. Appendix I: Lamprey airlifting method technical note

Rationale for using an alternative methodology to the *LIFE* protocol

- A number of studies have recorded sea lamprey adults spawning within a number of UK rivers. However, juvenile lamprey surveys indicate disproportionately low densities, or complete absence, of sea lamprey ammocoetes at sites where adults are known to be spawning (e.g. Harvey et al., 2006a ; Bellflask, 2003/2004 & 2005).
- There is evidence to suggest that the marginal silted habitat, currently targeted by the LIFE method, may be less utilised by sea lamprey ammocoetes (compared to Lampetra spp.) and that they may be utilising deeper (>2m) water (Taverny et al., 2012).
- Airlifting in the Welsh River Dee has so far found lamprey ammocoetes in sediment at water depths between 1.6 to 4.4m; both Lampetra spp. and sea lamprey are found at these depths (Teague et al., in prep.).
- Utilising the airlifting method, APEM has found that a greater proportion of sea lamprey ammocoetes (of the total number of lamprey ammocoetes captured) occurred in the 'deep water' samples, compared to the marginal habitat surveyed using the LIFE method.

Methodology

- The method utilises a "Mackey/Yorkshire pattern air-lifter", which is deployed from a boat
  - The sampler is placed on the riverbed, held in a vertical position, and an air supply turned on to a pressure great enough to lift water, sediment and lampreys up the delivery pipe and through a collecting net (with a 1 mm mesh to ensure the collection of all lamprey ammocoete age classes).
  - A sample is collected by 'bouncing' the air-lift sampler on the riverbed within a localised area (approximately 0.5 to 1m2).
  - Currently the area sampled cannot be precisely quantified; therefore the results obtained are semi-quantitative.
  - APEM is currently developing and trialling the method to be made fully quantitative.
- After the sample is collected:
  - The collected sediment is sieved to retain the lamprey ammocoetes
  - The lamprey ammocoetes are identified, measured and enumerated.
  - An estimate of the sediment composition (relative proportion of sand, silt, and organic debris) is made.
- This method has been shown to capture all lamprey ammocoetes in good condition, and thus they are released back into the watercourse alive.

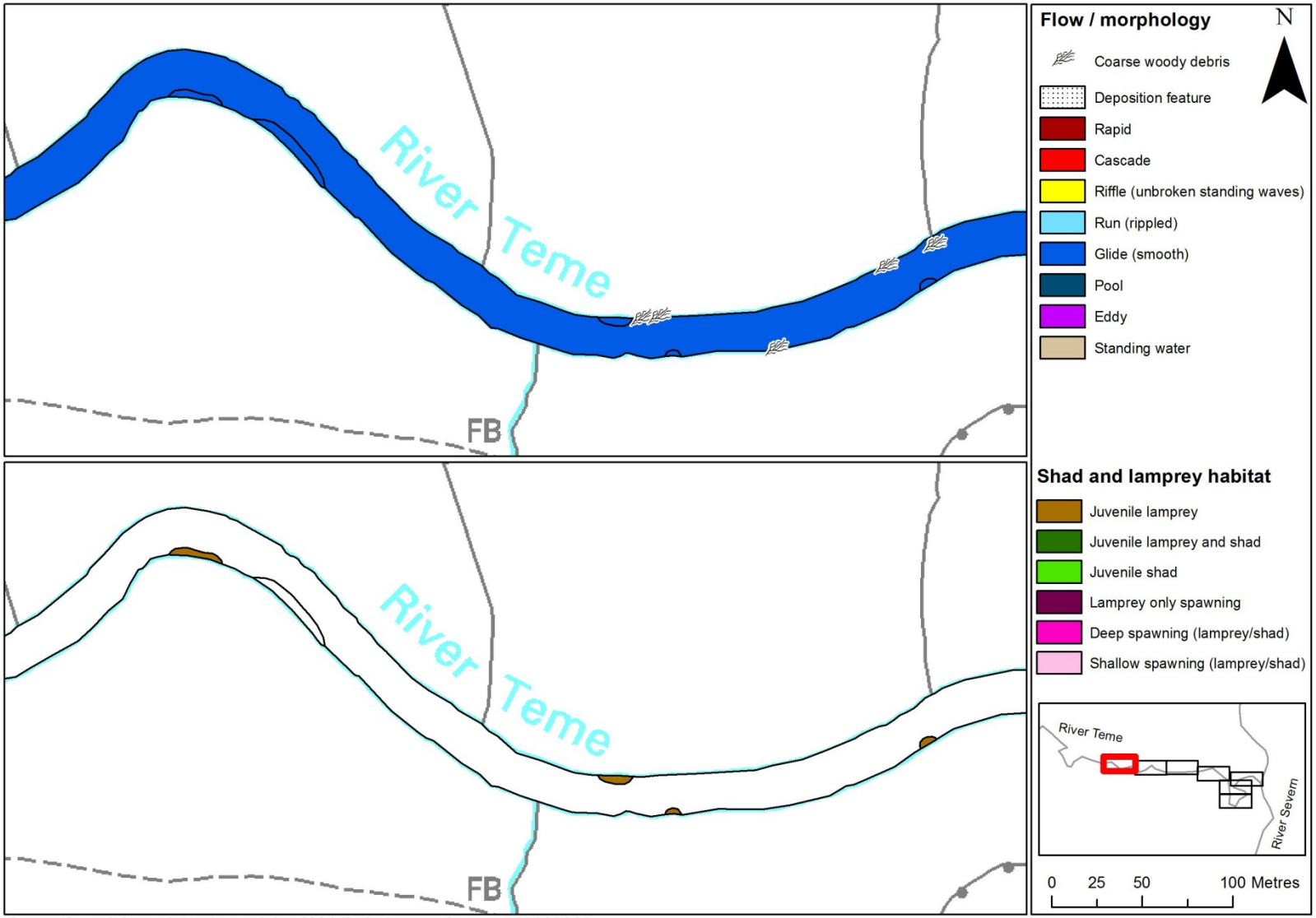
Case Study: The River Dee (Teague *et al*., in prep)

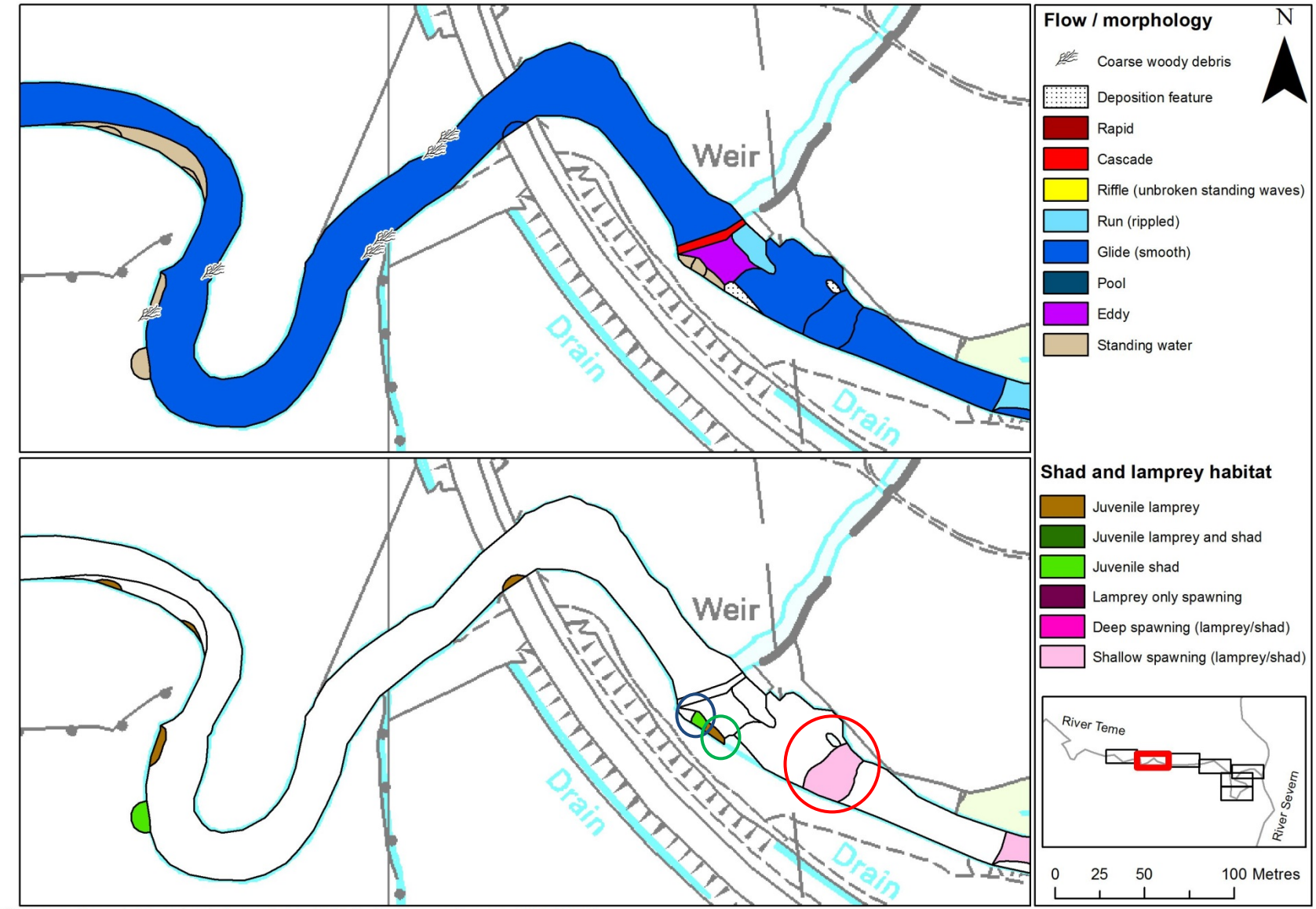
To trial the air-lifting method, sampling was carried out on the lower and middle reaches of the Welsh River Dee during June 2007. A total of 193 air-lift samples were collected over 134 sites. To enable comparison between deep water and marginal lamprey catches, standard quadrat based quantitative electric fishing surveys (following the *LIFE* protocol) were carried out at 46 sites within shallow marginal habitat using the common standard monitoring methodology.

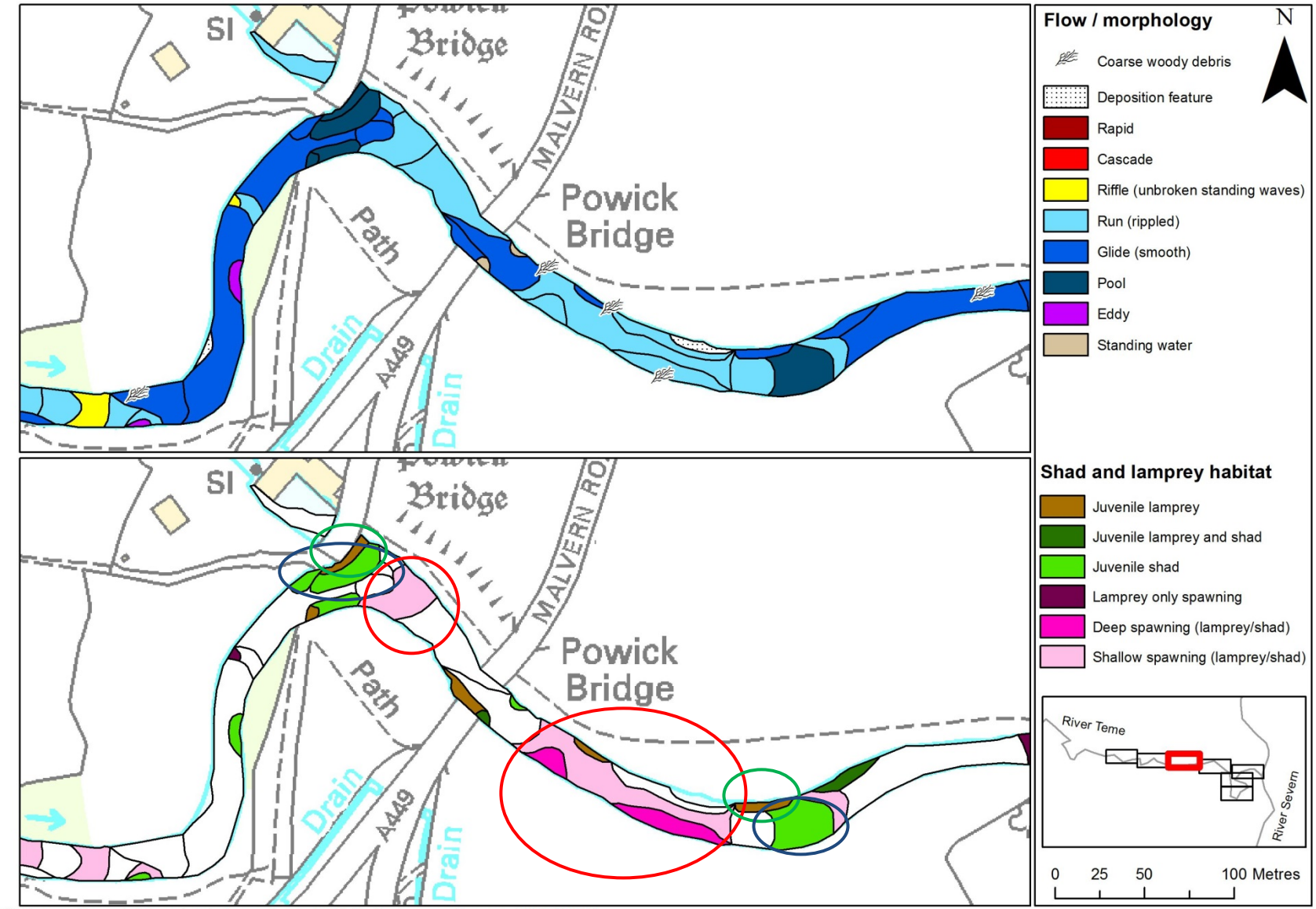
Of the 46 electric fished sites, 39 recorded lamprey ammocoetes but only 1 (0.57%) sea lamprey ammocoete was identified (of a total of 174 lamprey ammocoetes), all others being *Lampetra* spp. In comparison, 66 of the air-lifted samples contained at least 1 lamprey ammocoete, with a total of 48 sea lamprey recorded in 27 samples and over 10 sites. *Lampetra* spp. were found in 53 of the air-lifted samples, and the ratio of *Lampetra* spp. to sea lamprey was 2.2:1. This is a greater proportion of sea lamprey compared to the 1 in 50 ratio determined for the UK from standard electric fishing sampling techniques (JNCC, 2005), and indeed also compared to the ratio of sea lamprey found in the 46 electric fished sites surveyed during this study (174:1).

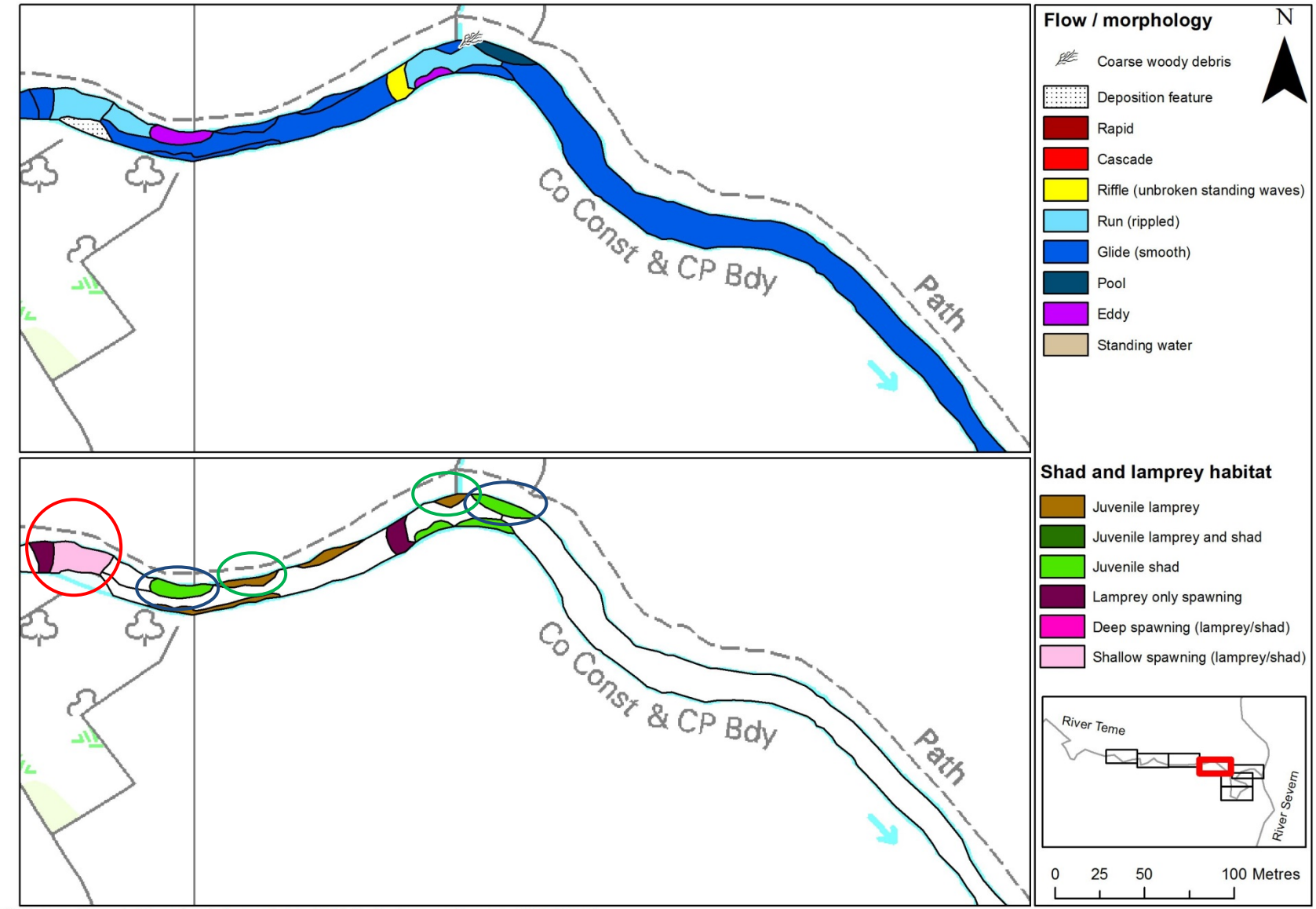
These findings illustrate the paucity of information concerning habitat usage by sea lamprey (and *Lampetra* spp.) and the requirement to consider lamprey conservation statuses throughout a range of habitats, not solely the marginal habitat as is the current practice.

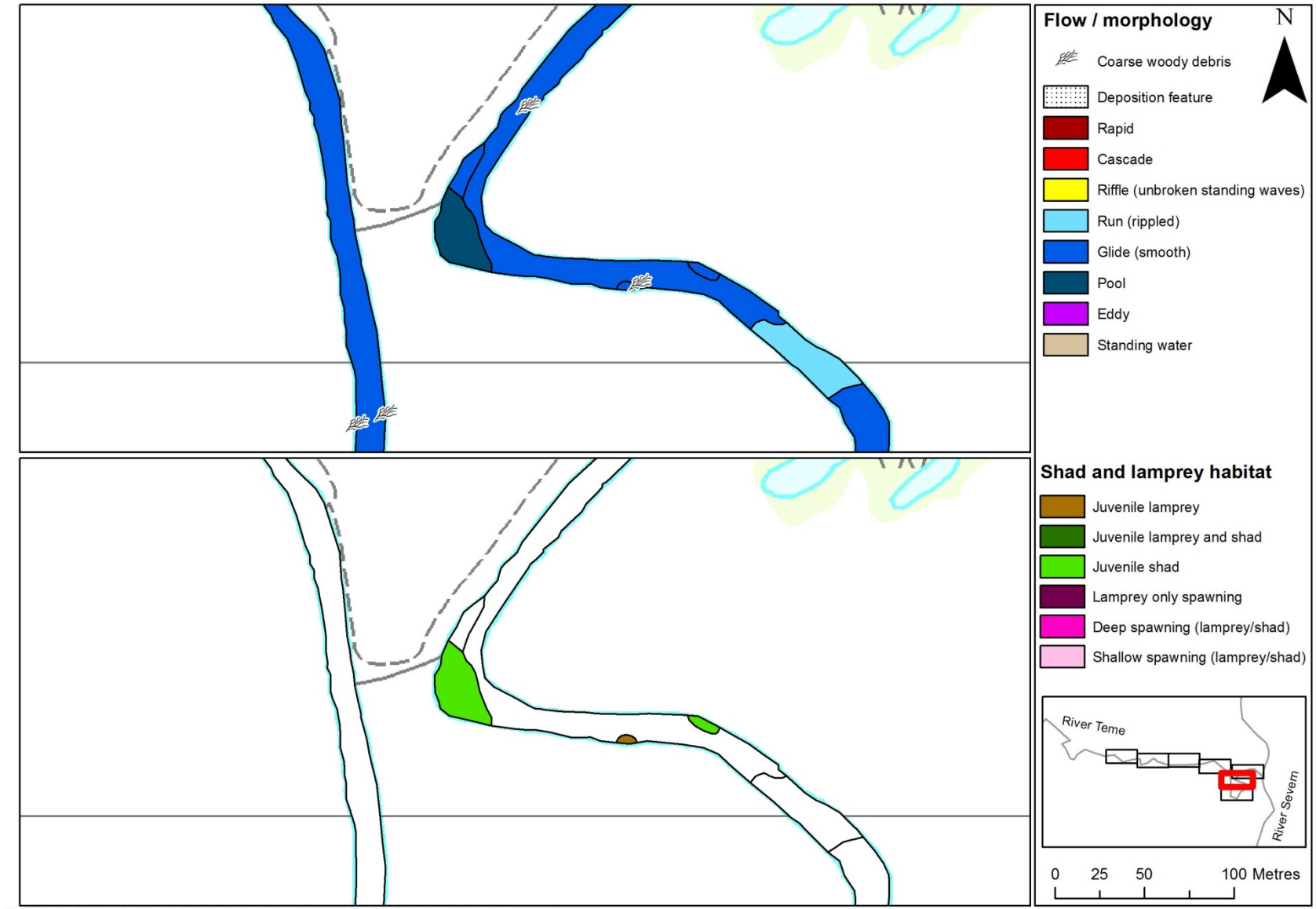
7. Appendix II: Maps of the River Teme survey results (ordered from upstream to downstream)

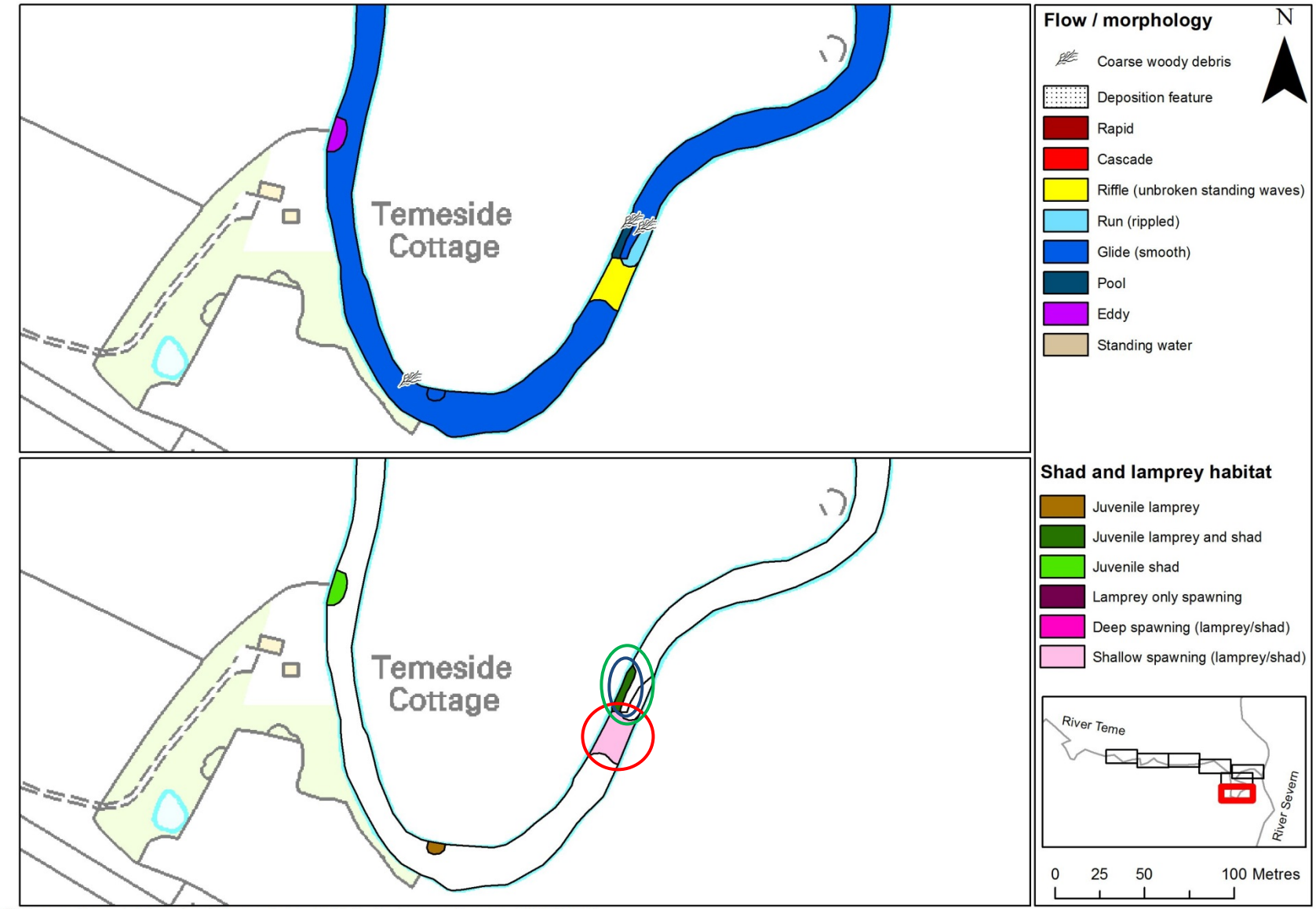


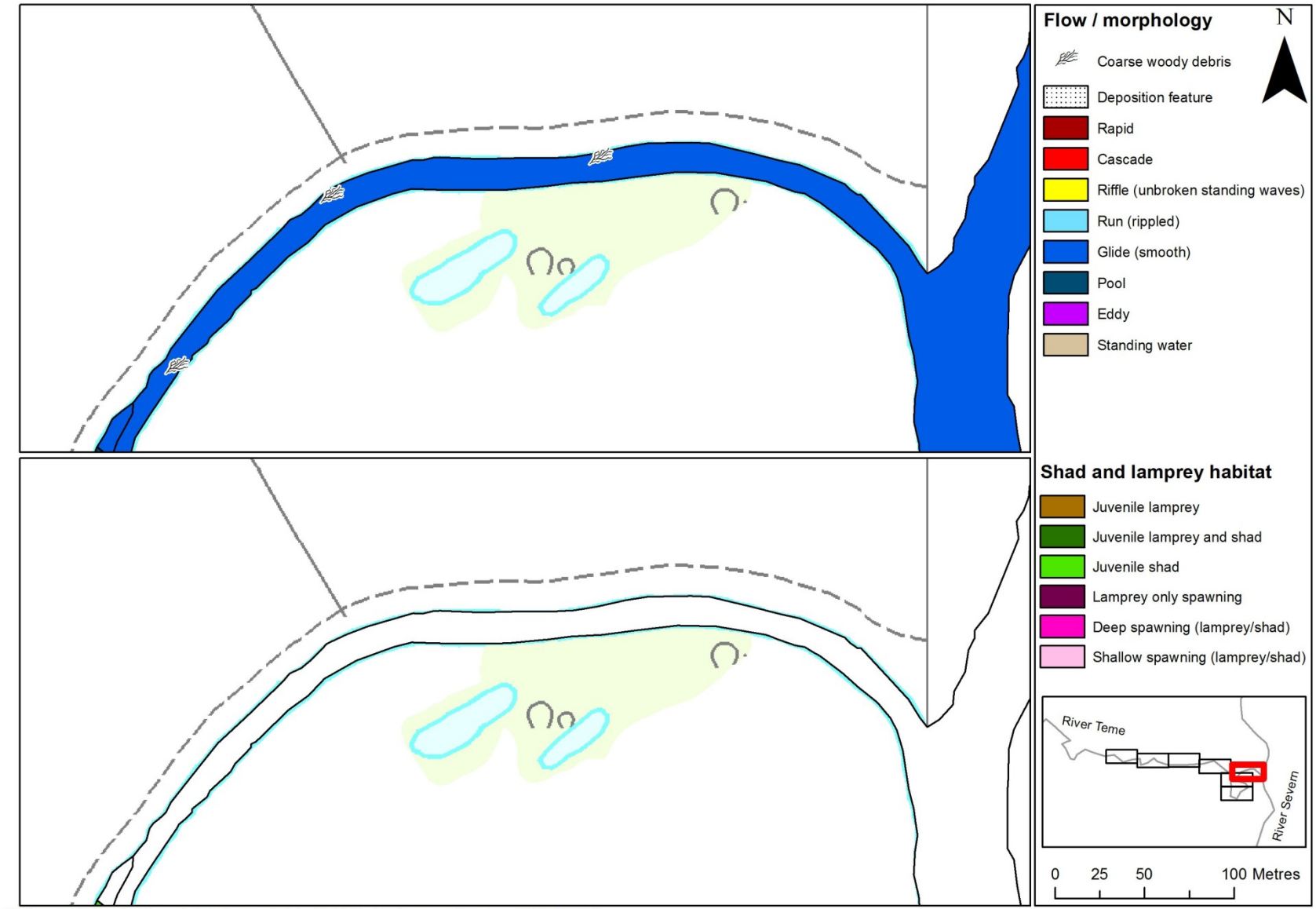




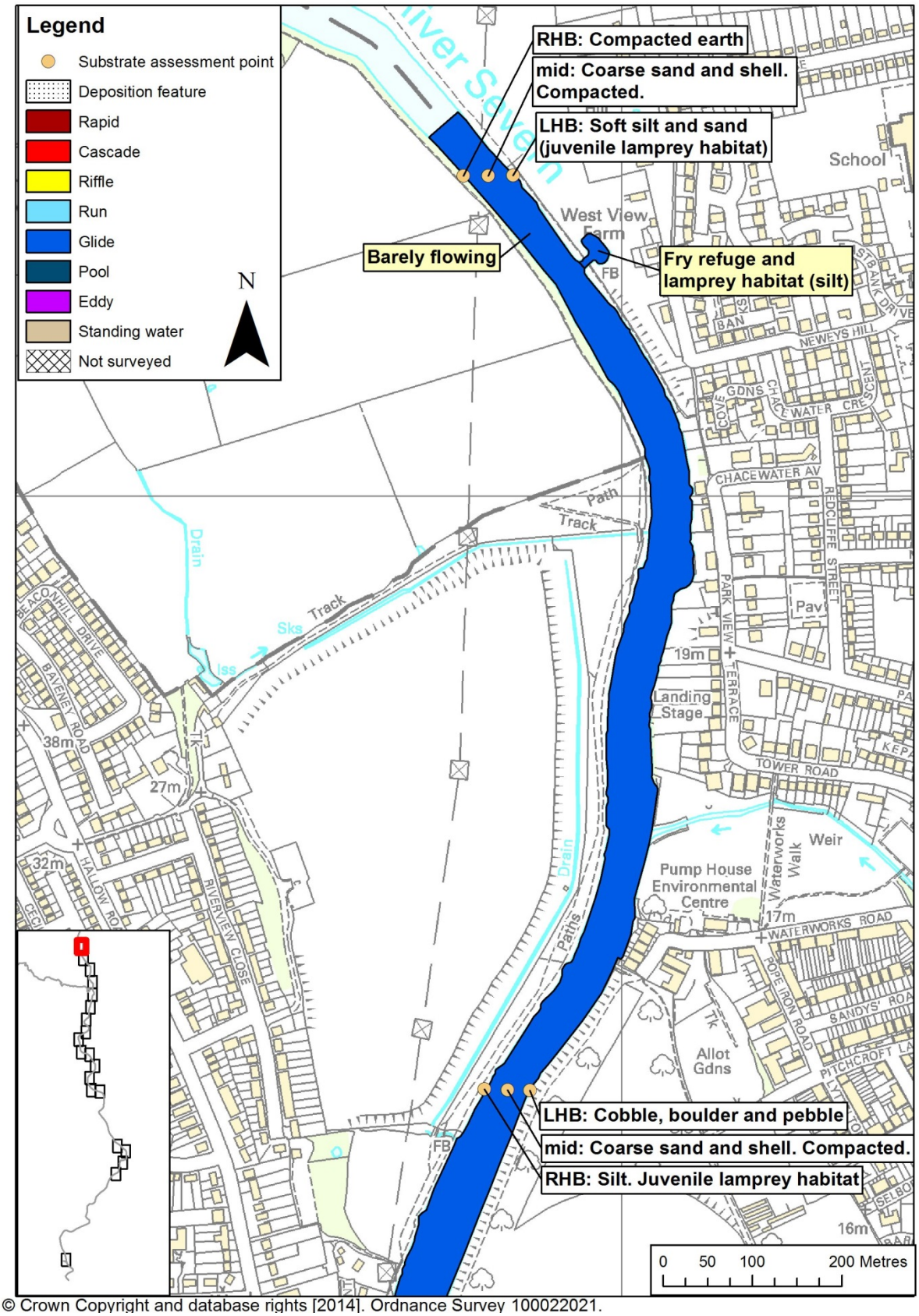


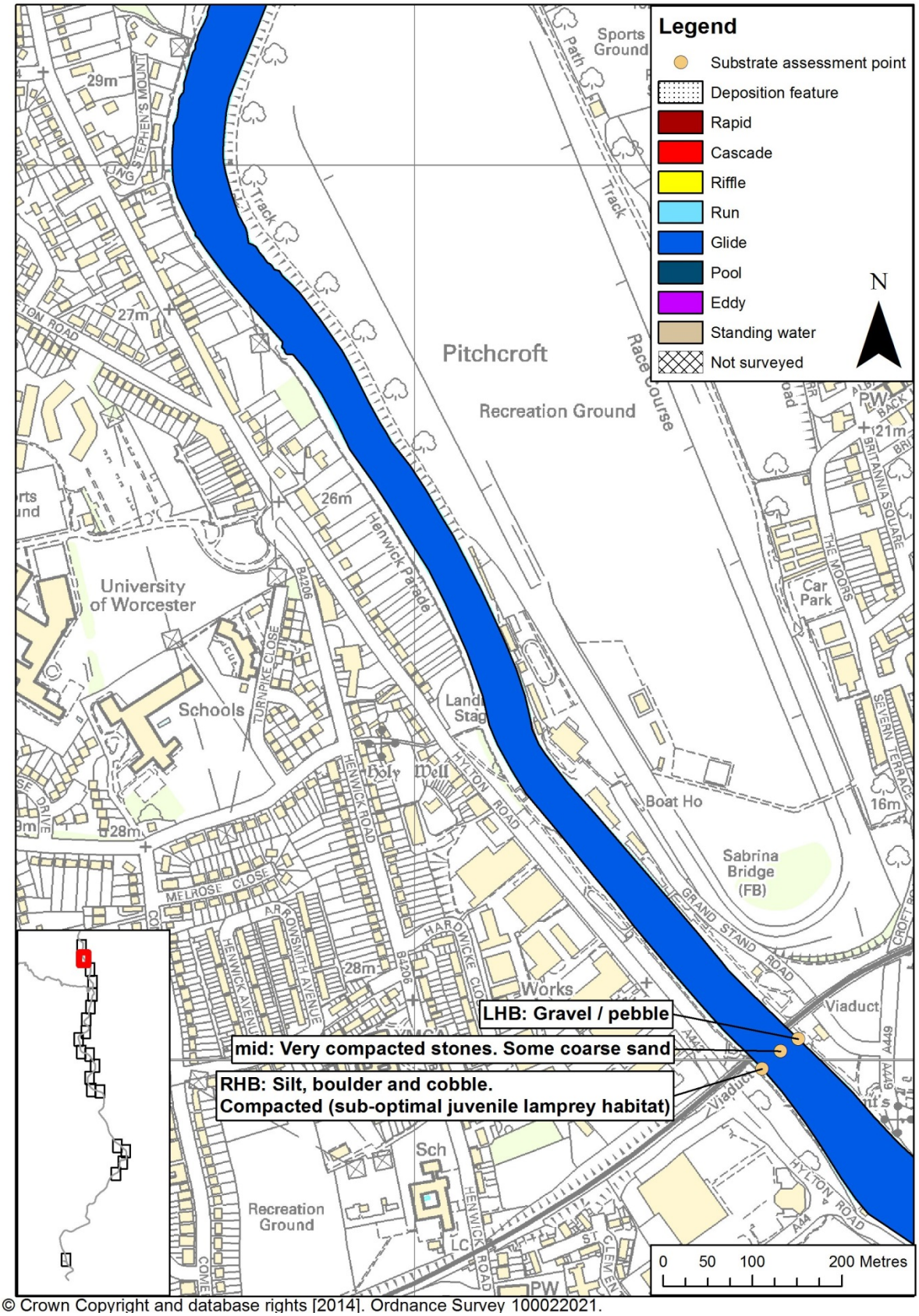


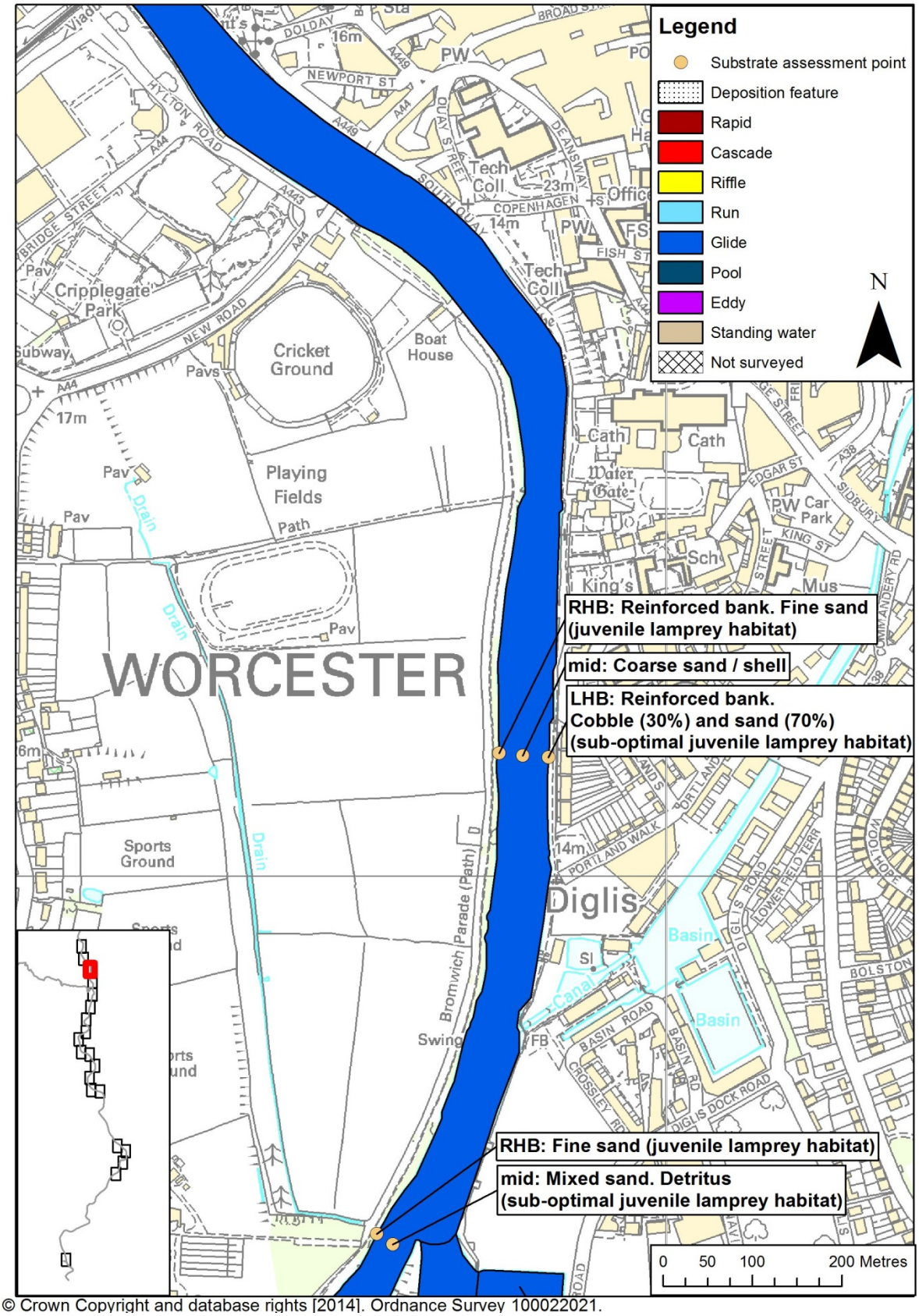


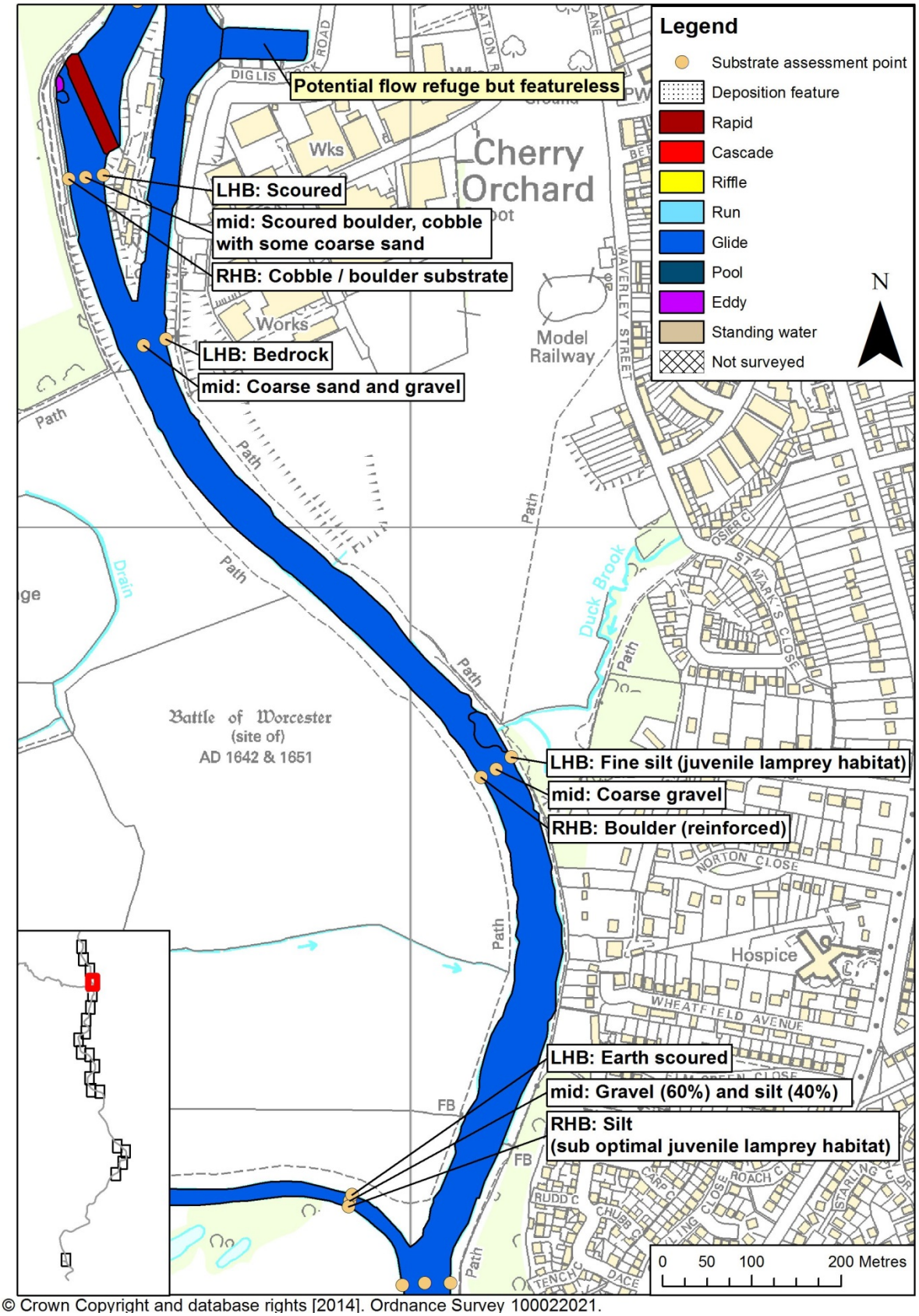


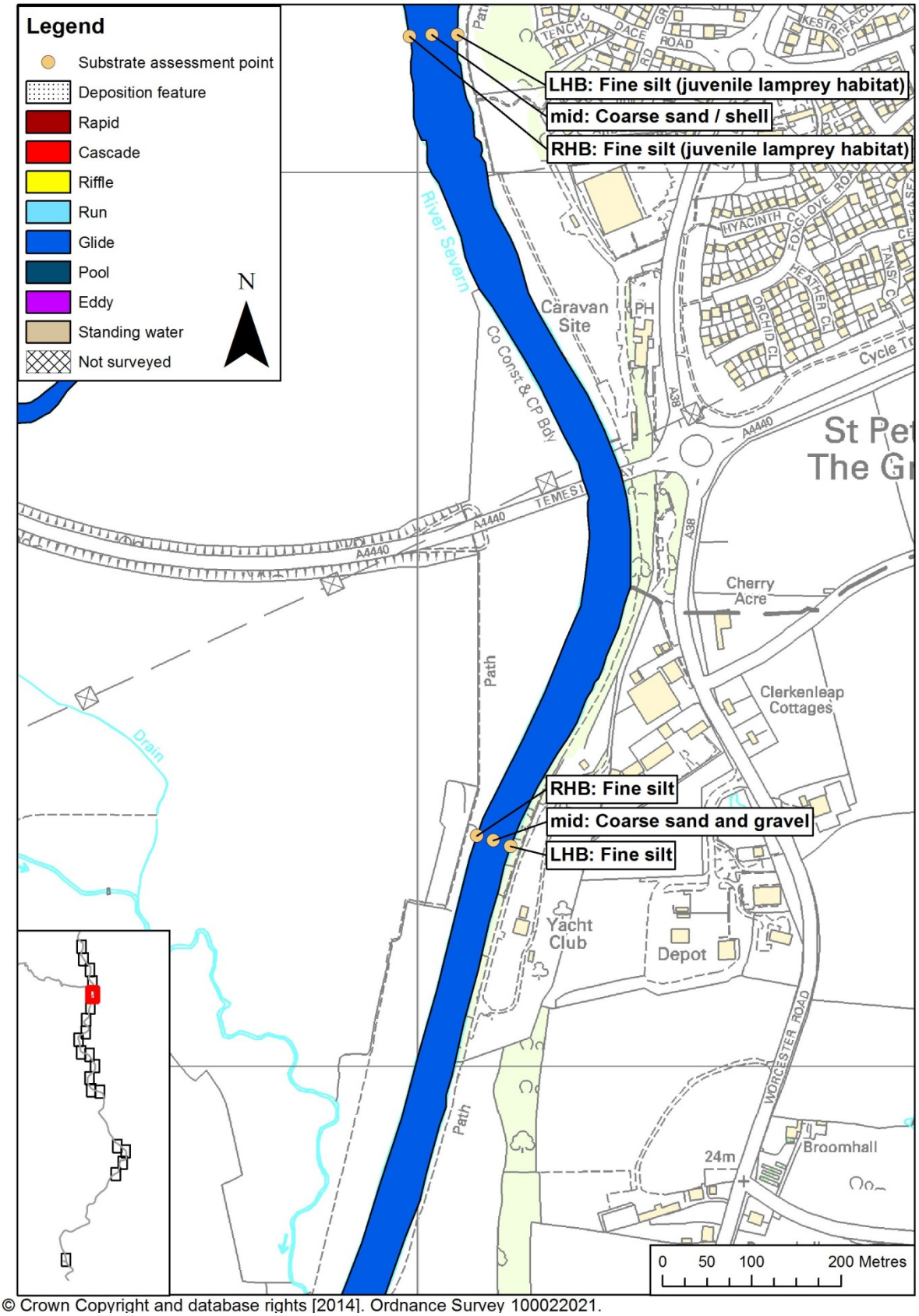
8. Appendix III: Maps of the River Severn survey results (ordered from upstream to downstream)

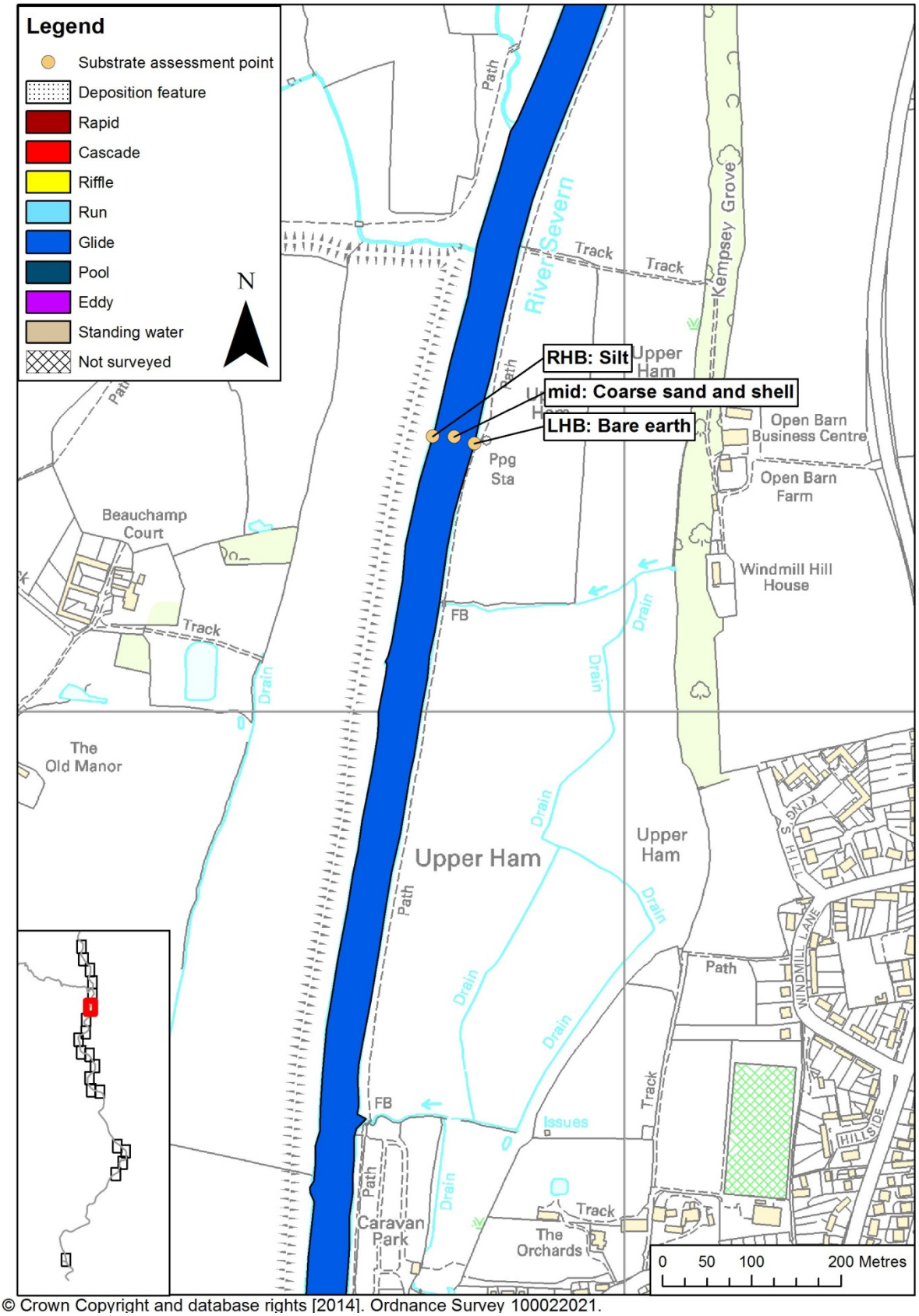


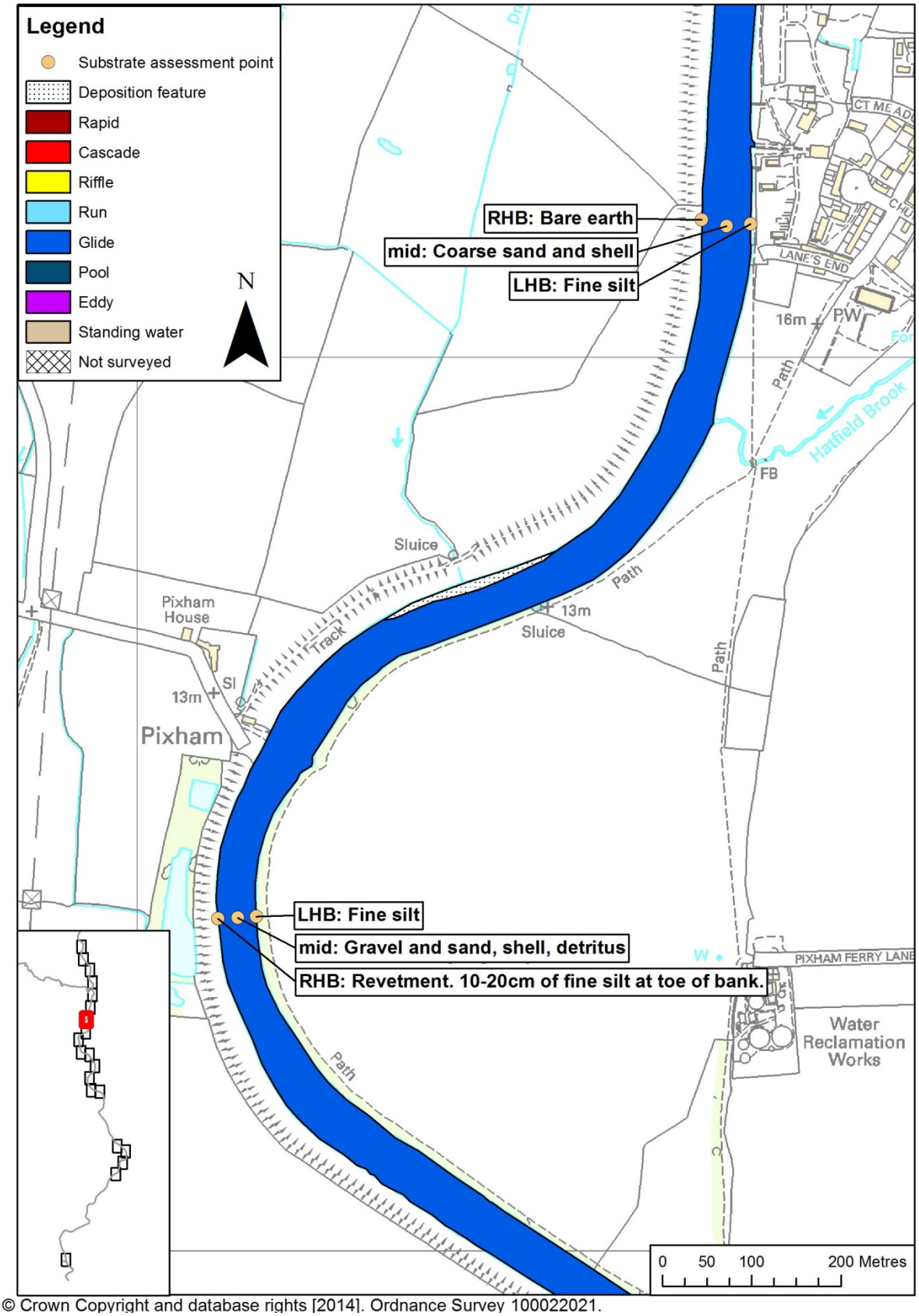


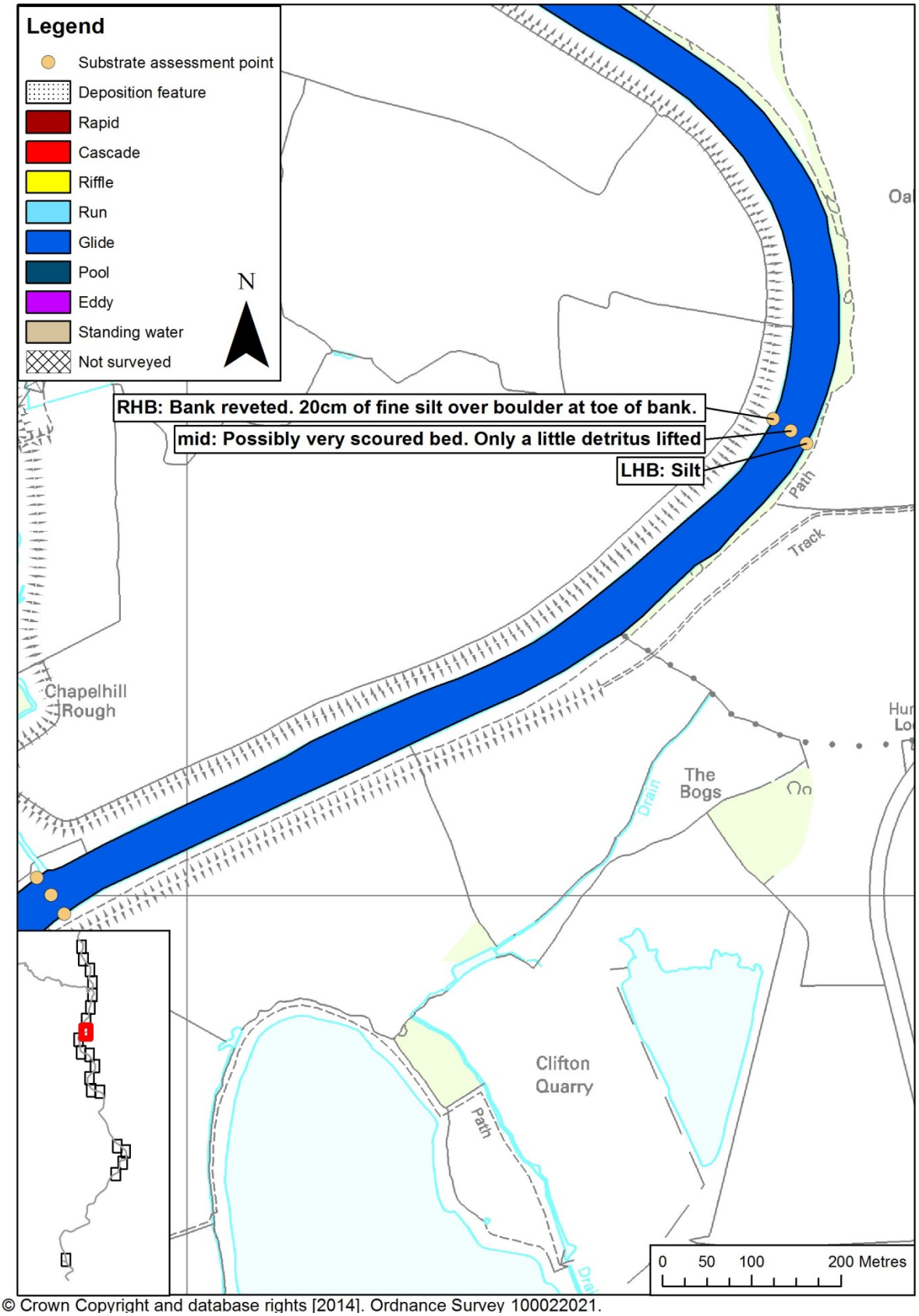


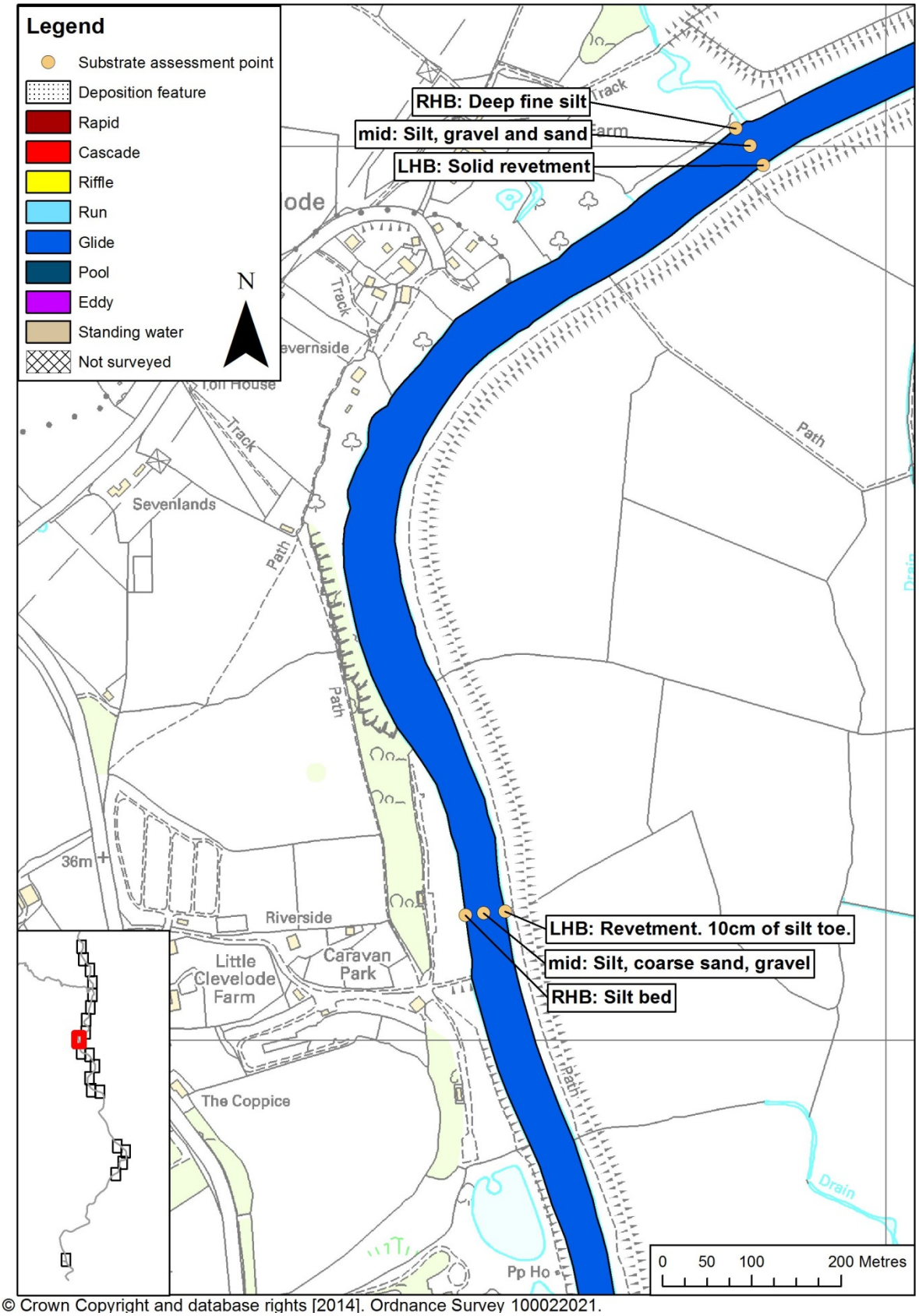


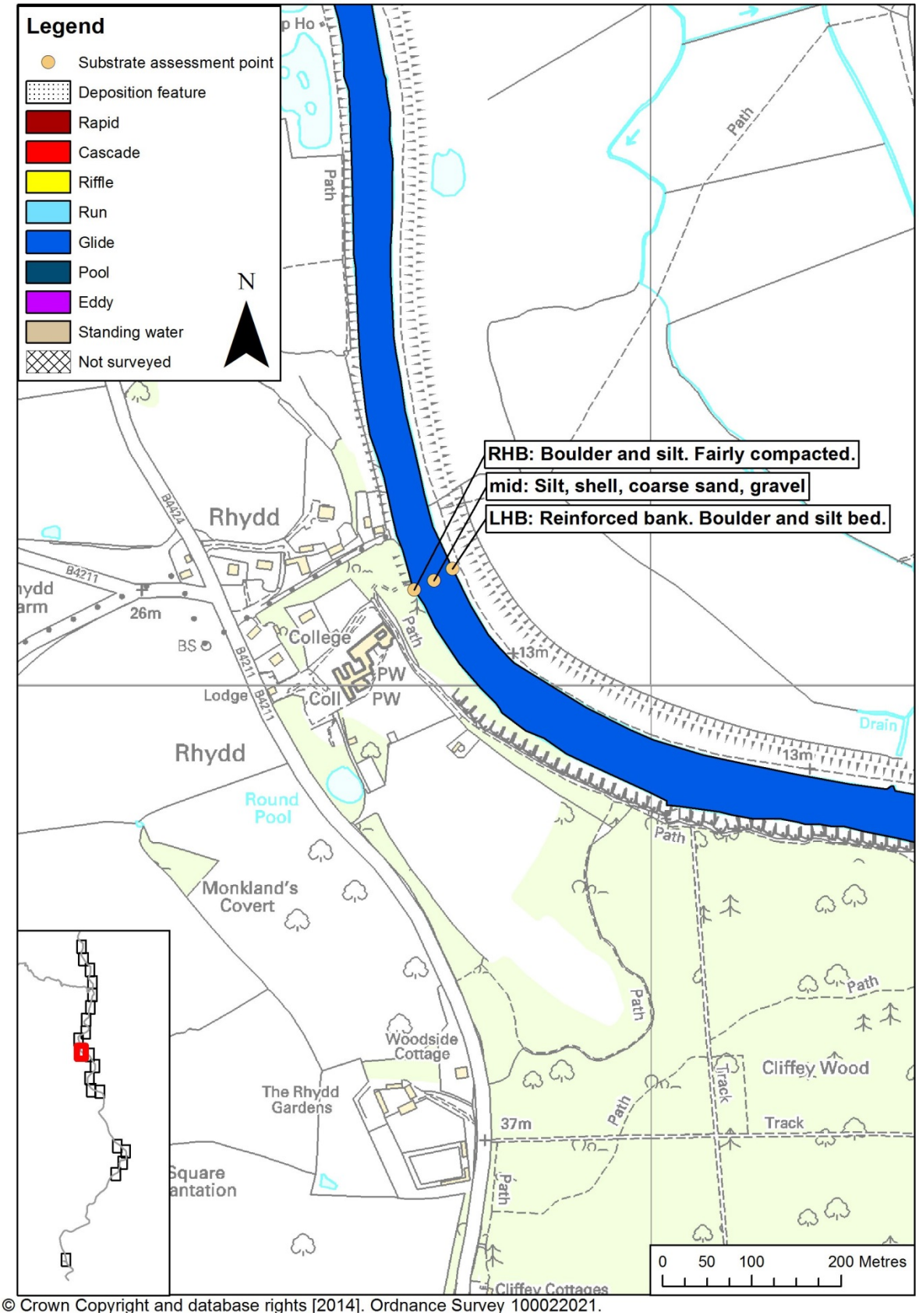


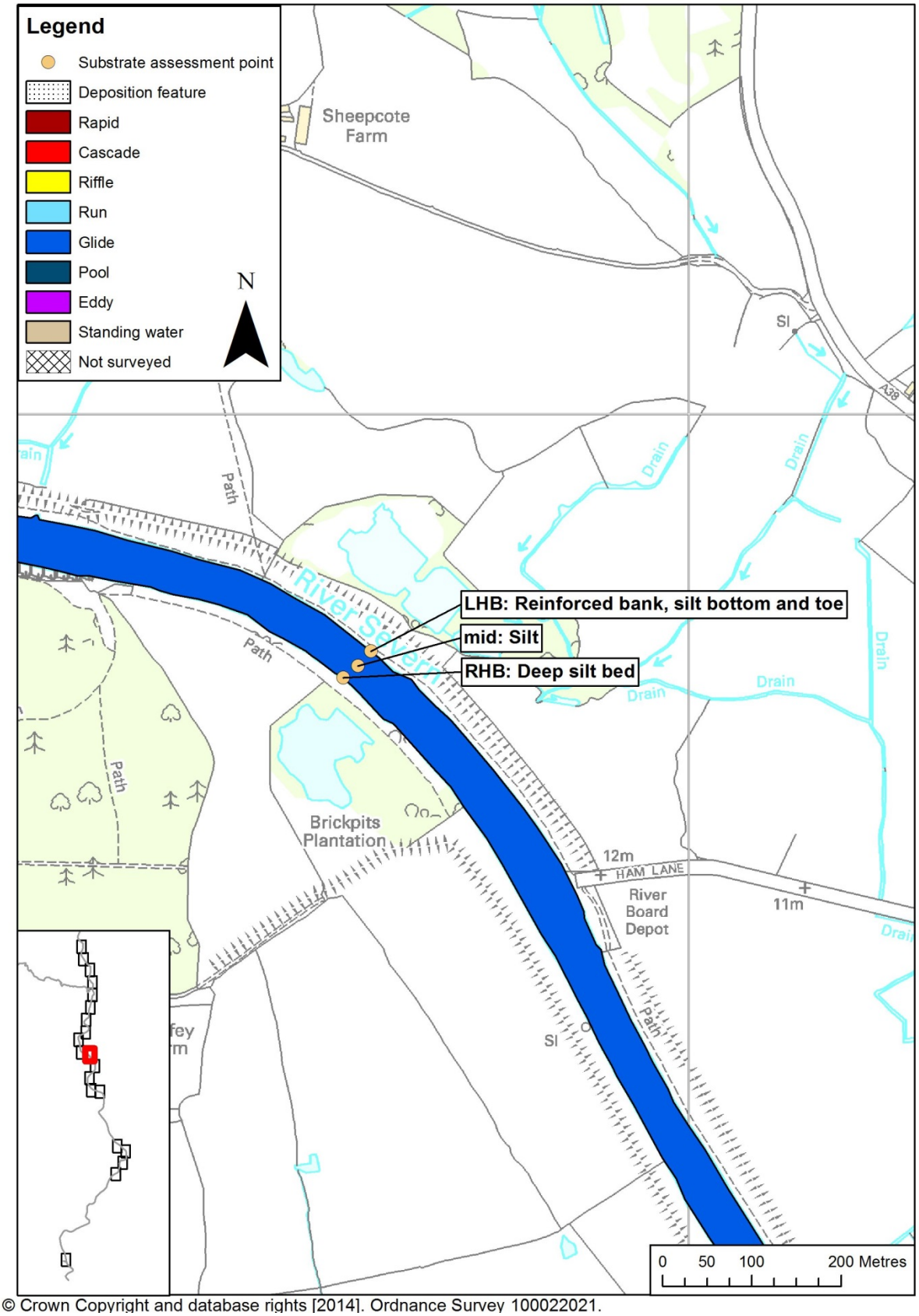


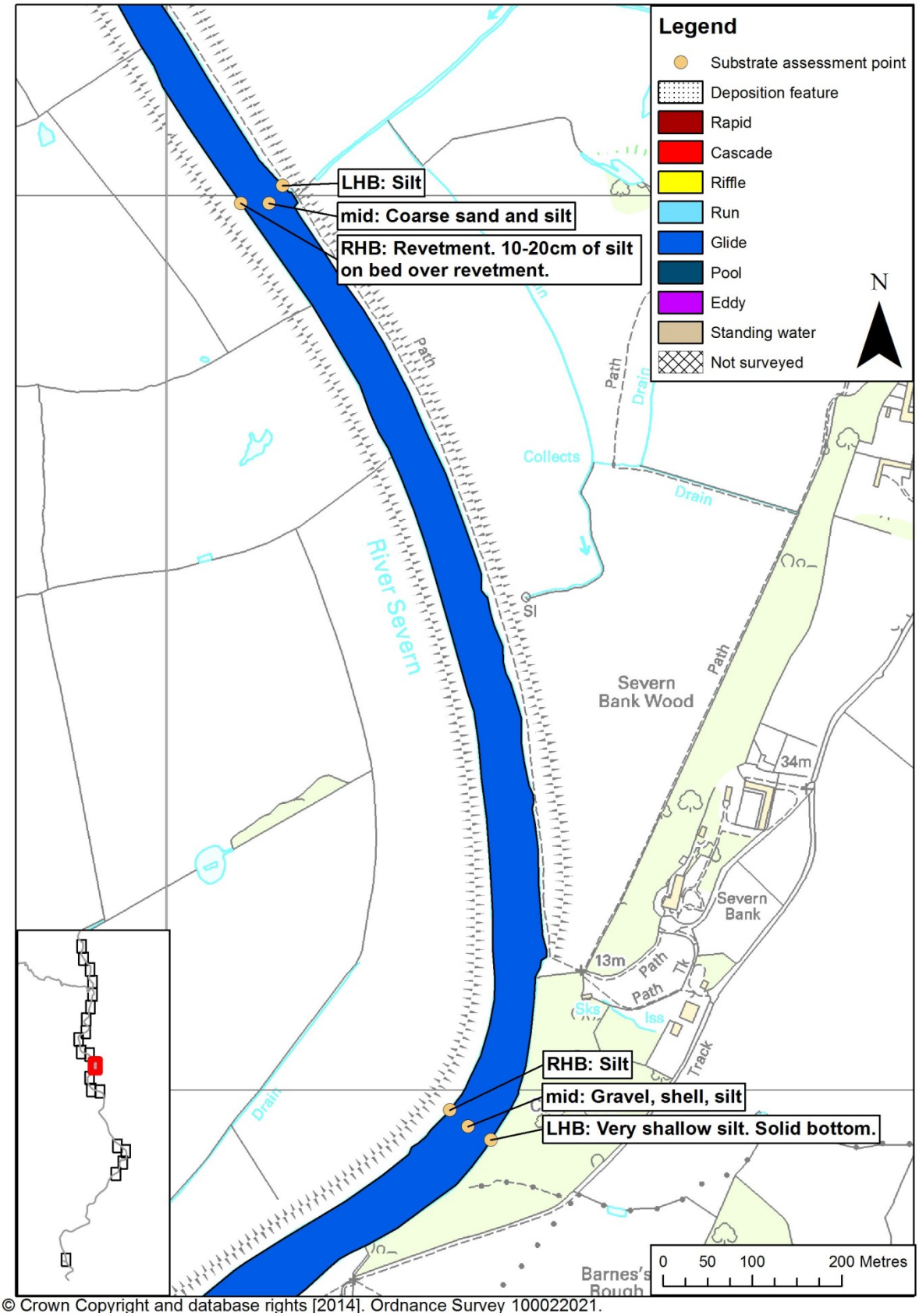


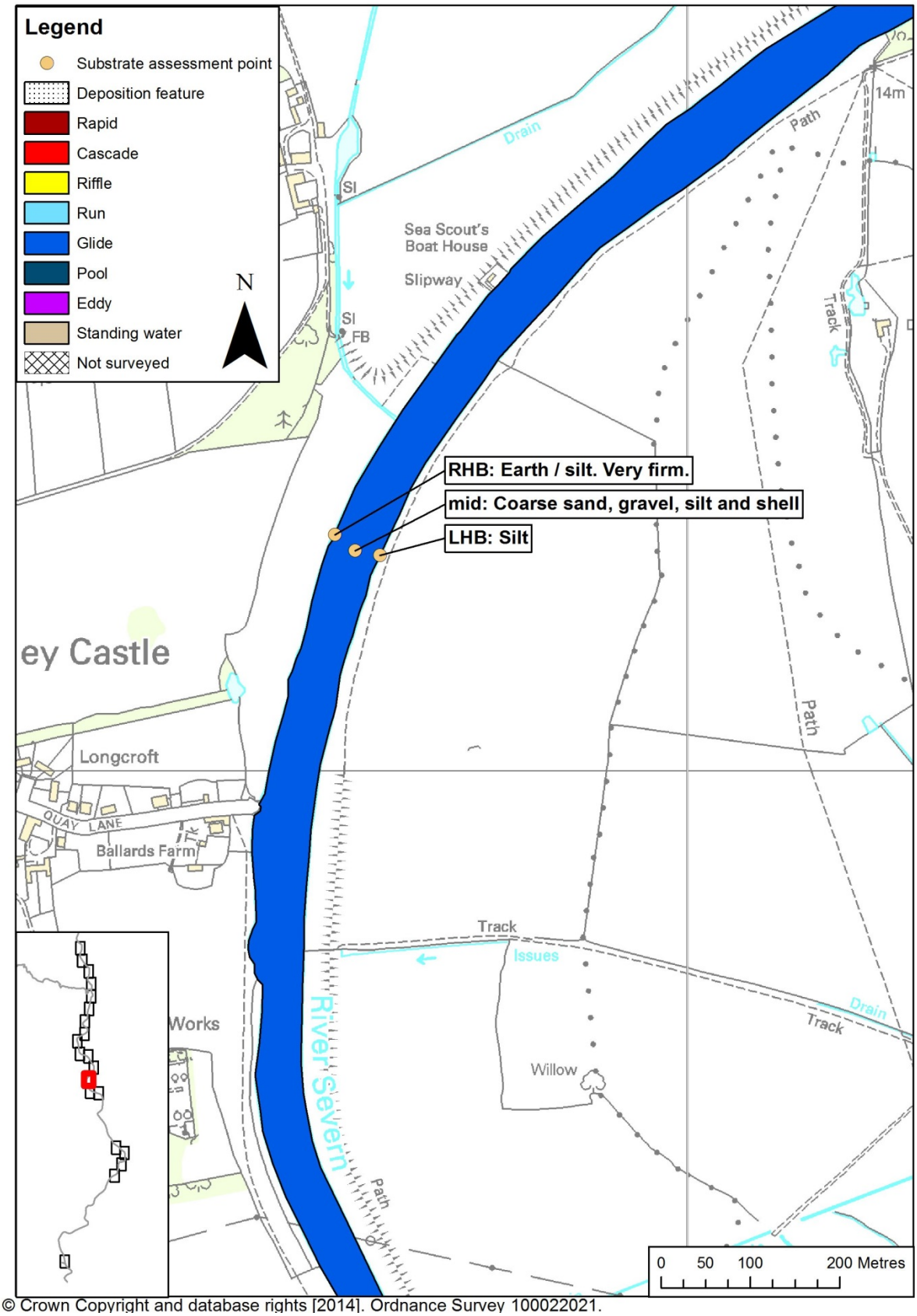


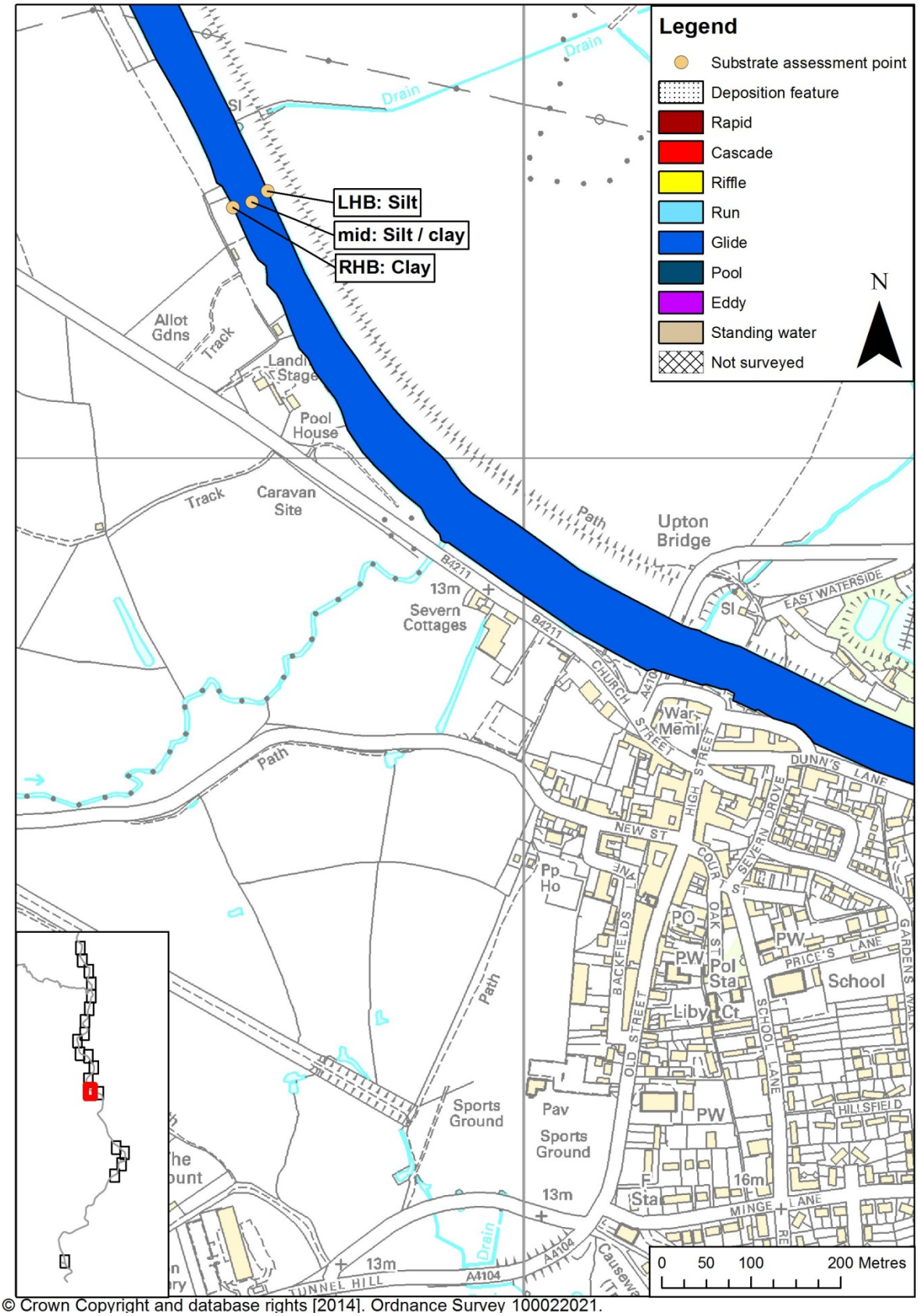


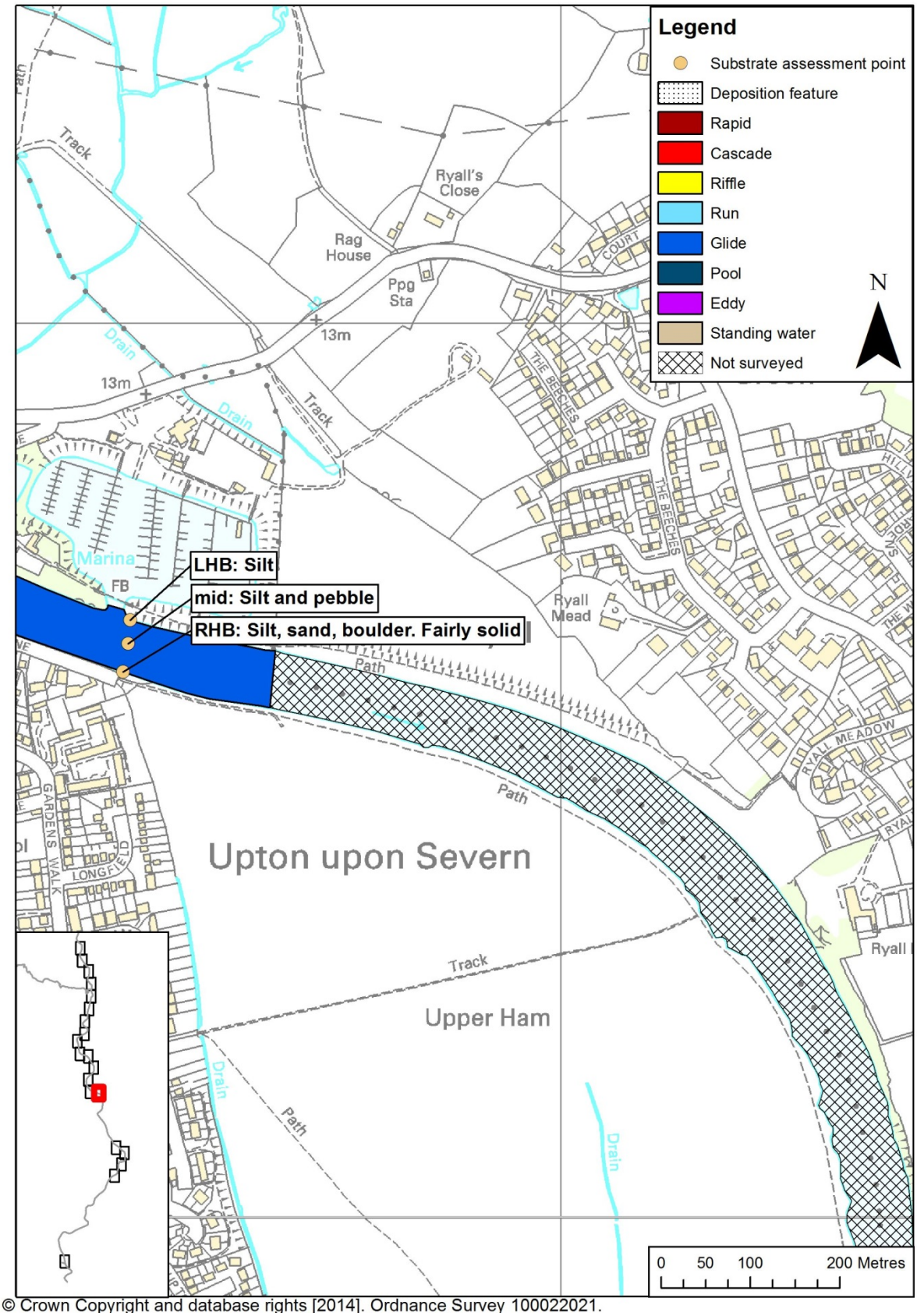


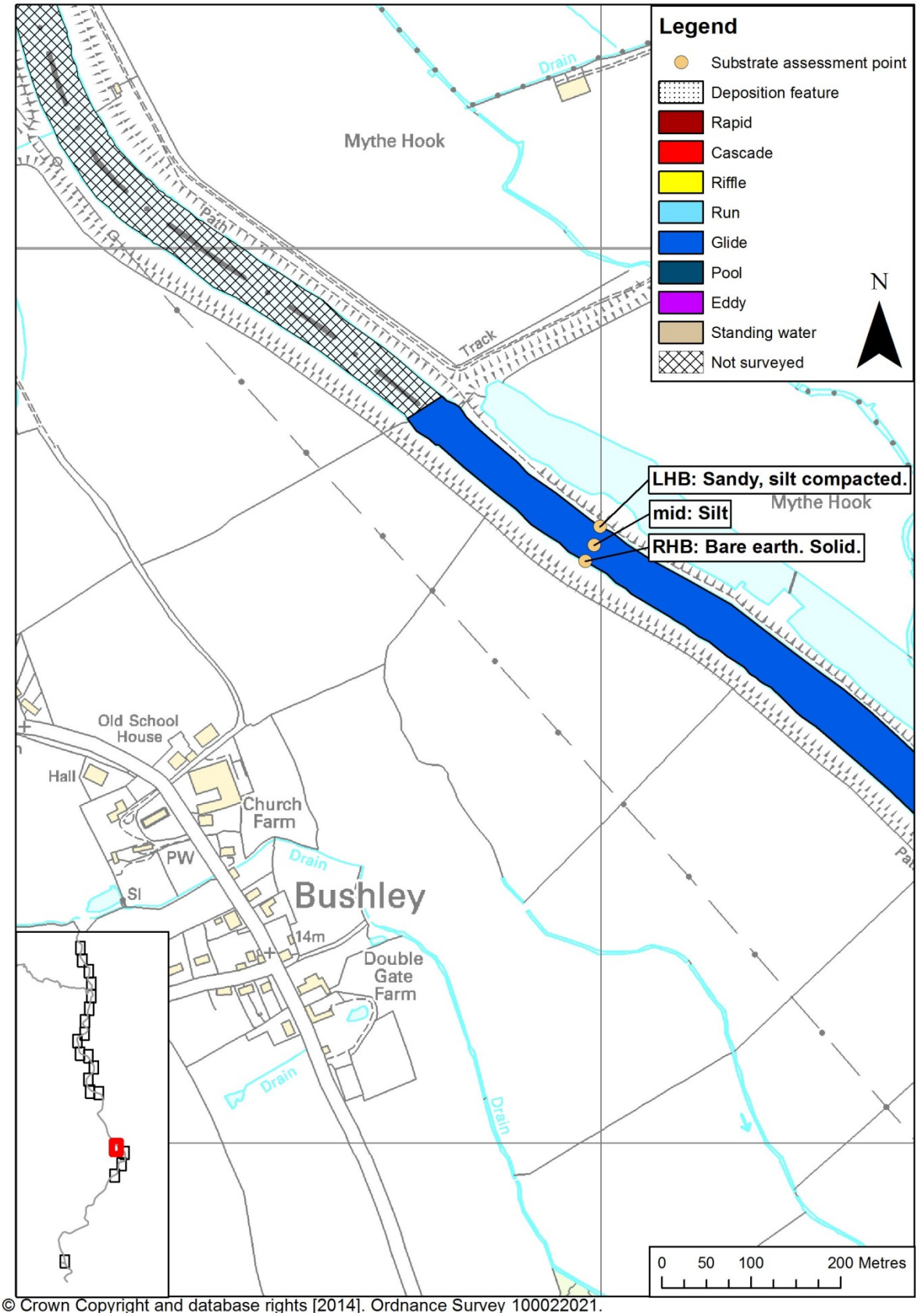


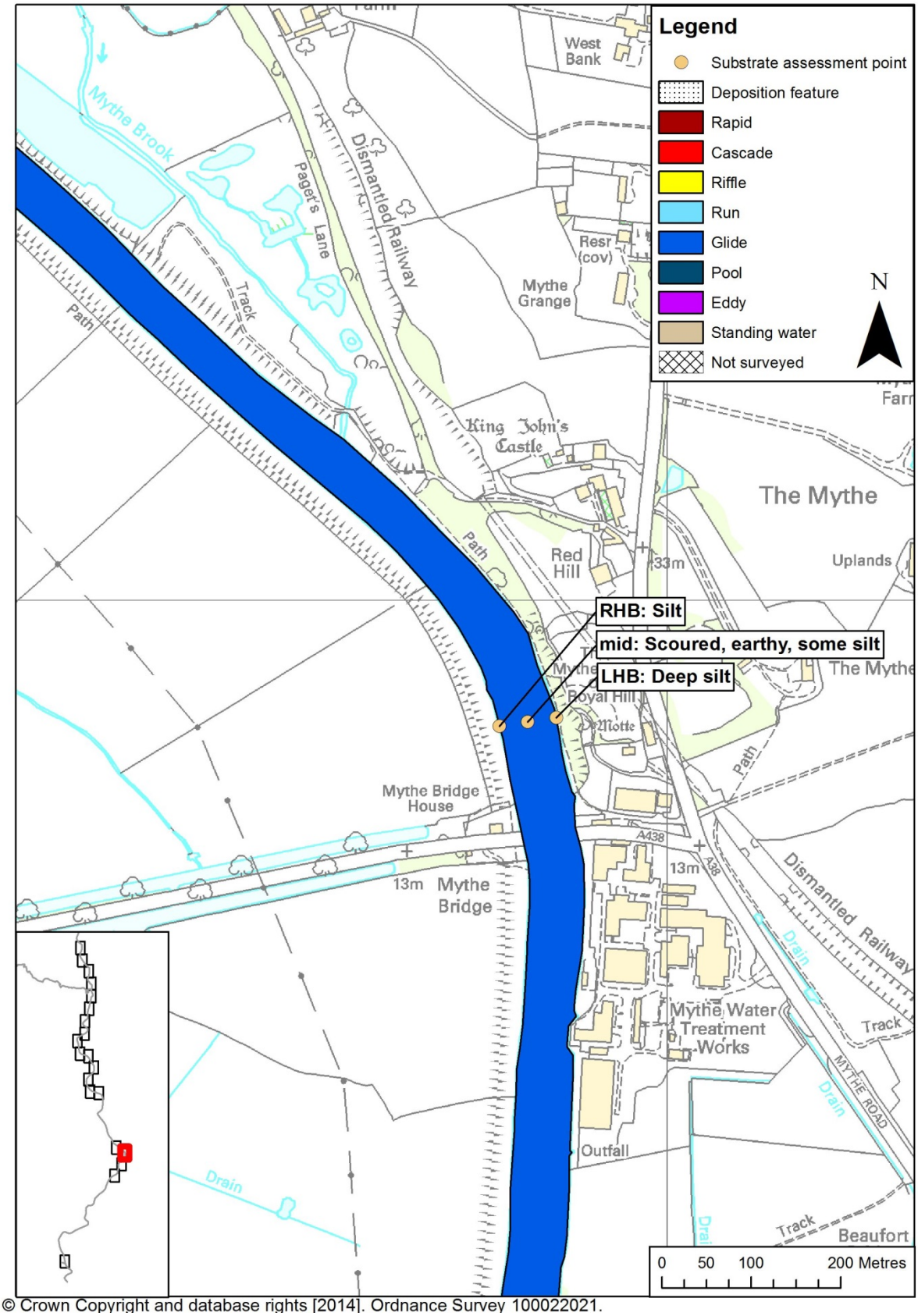


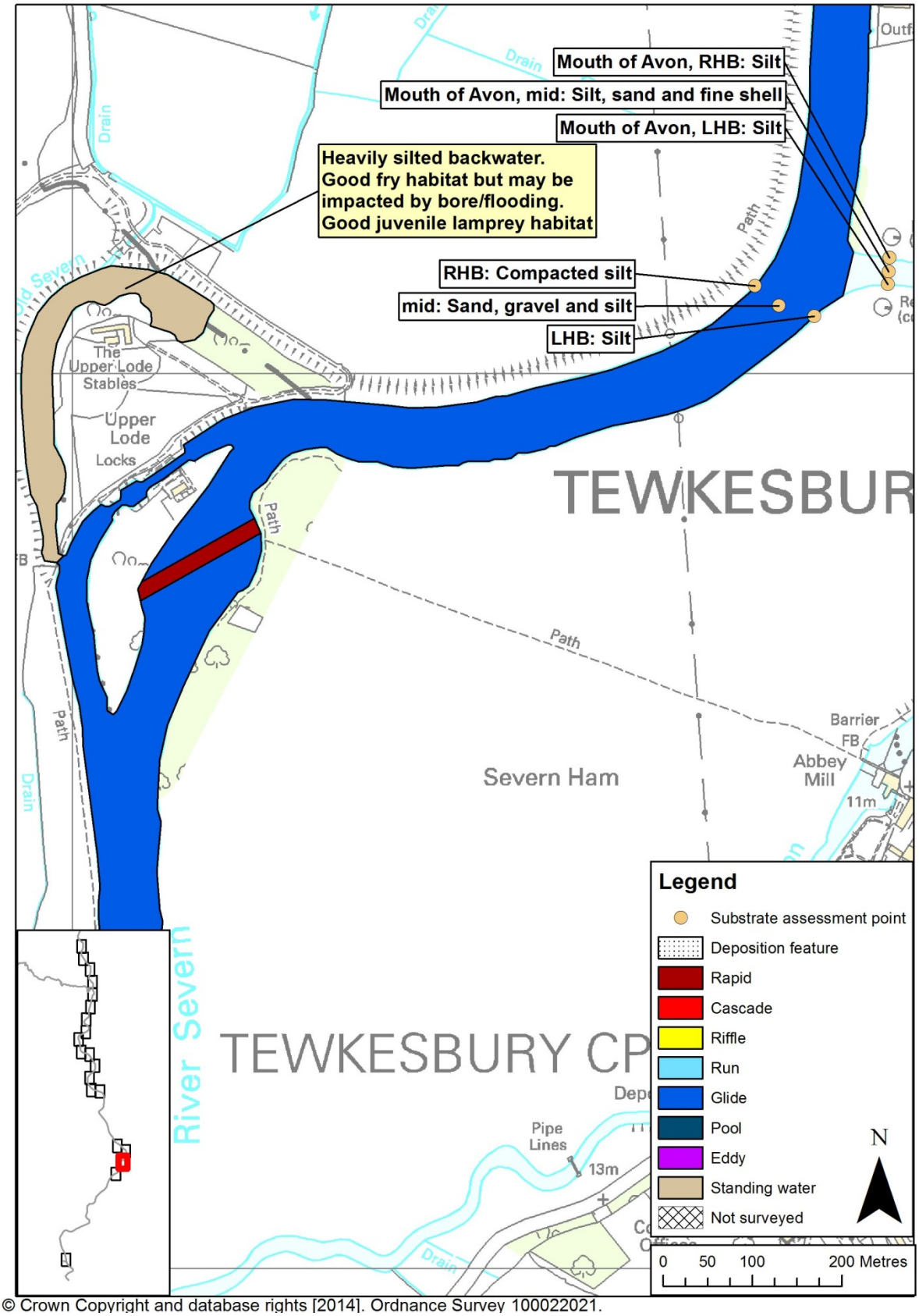


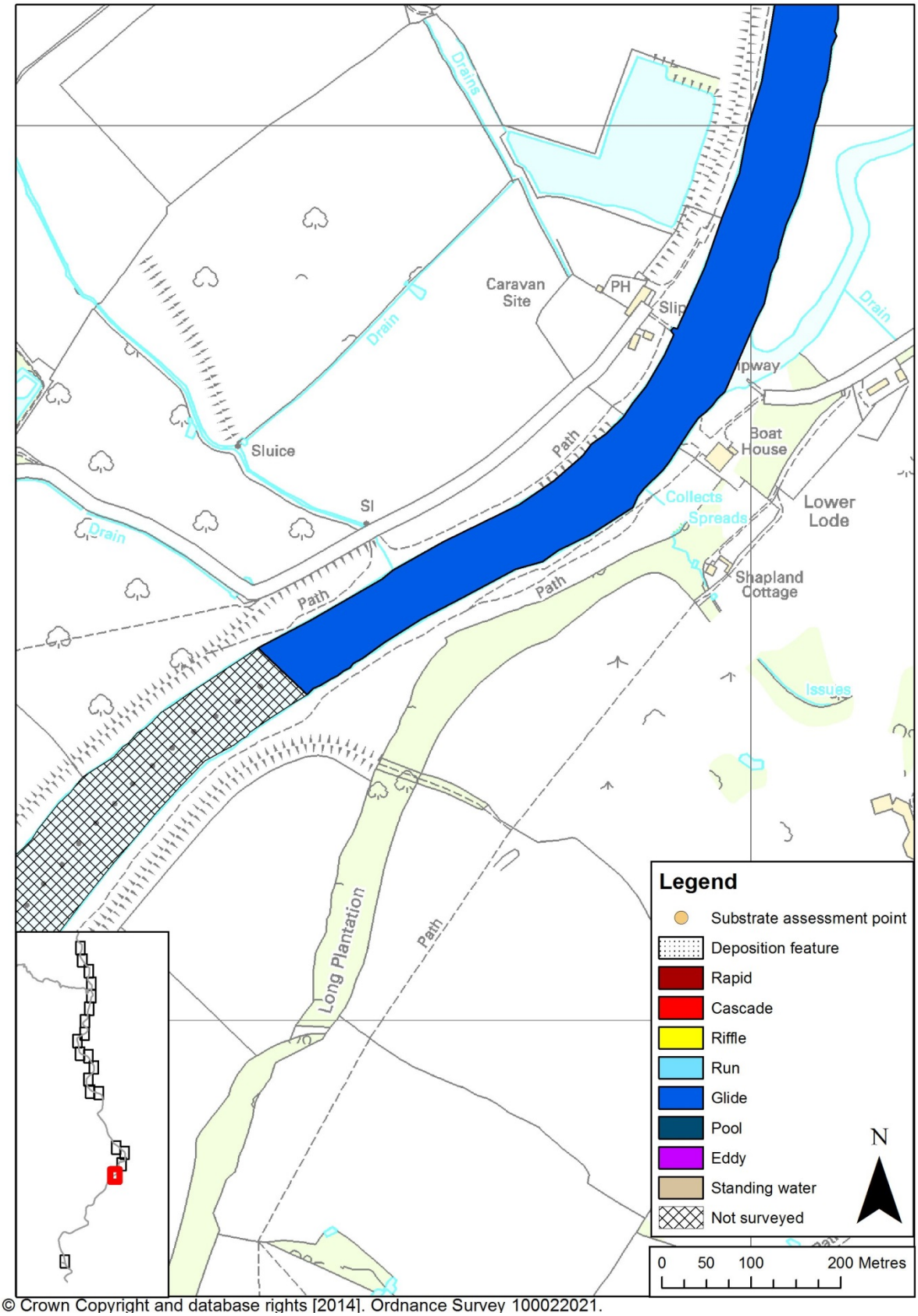


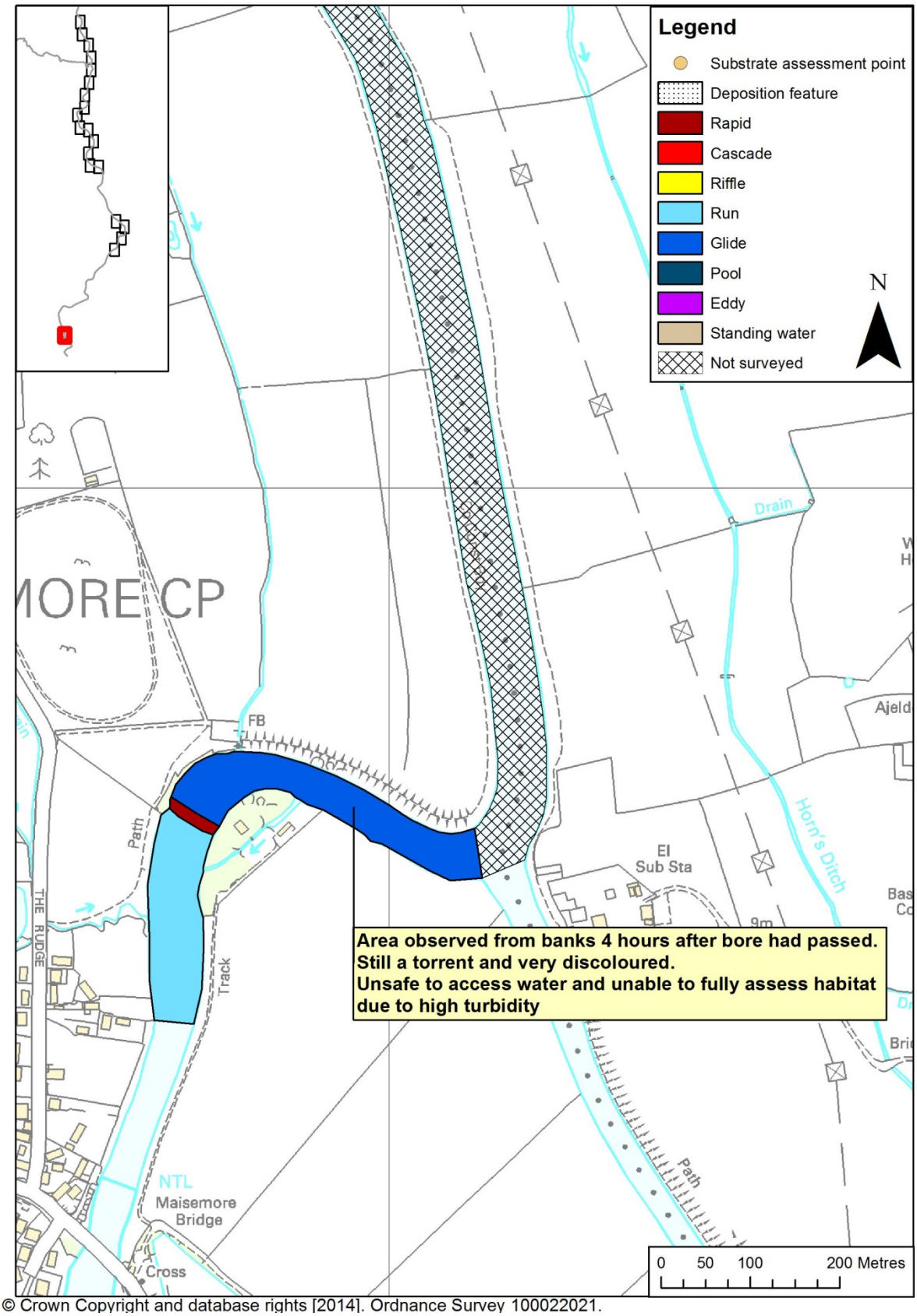












Further information

Natural England evidence can be downloaded from our **Access to Evidence Catalogue**. For more information about Natural England and our work see **Gov.UK**. For any queries contact the Natural England Enquiry Service on 0300 060 3900 or e-mail **enquiries@naturalengland.org.uk**.

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