Aquatic Invertebrate and Mussel Survey

Oxford Flood Alleviation Scheme

Environment Agency

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1. Introduction

AECOM was commissioned by the Environment Agency to undertake aquatic macroinvertebrate and freshwater mussel surveys of several waterbodies in Oxford, Oxfordshire, to support the Environment Agency's assessment of potential impacts associated with the Oxford Flood Alleviation Scheme (FAS).

The surveys concentrated on the River Thames and several of its tributaries that have the potential to be impacted by the FAS. The watercourses in questions are shown in the site plan in Appendix A.

The objectives of the surveys are to provide baseline data for aquatic macroinvertebrates communities of these waterbodies and gather data on the diversity of unionid mussels species present, in particular the depressed river mussel (*Pseudanodonta anatina*).

The Environment Agency selected sample sites on 13 waterbodies identified as being potentially affected by the FAS, and collected of macroinvertebrate samples on each of these sites in spring (May) 2016. AECOM then carried out a second macroinvertebrate a survey of each of these sites in autumn (September) 2016. In addition, AECOM also conducted specialised freshwater mussel surveys at ten of these sites at the same time.

The data will be used in order to inform design decisions, mitigation and future monitoring of the waterbodies, and help determine design and mitigation decisions as part of the scheme.

2. Method

2.1 General

The survey area lies south west of Oxford, between Botley in the north and Sandford-on-Thames in the south, as shown in the site plan in Appendix A. The waterbodies surveyed comprise the River Thames, several of its tributaries, including ditches and streams, and one pond (Kennington Pit).

2.2 Sample Site Locations

Sampling focused on the River Thames, Hinksey Stream and several of their tributaries potentially affected by the scheme. A total of 13 sampling locations on watercourses potentially impacted by the FAS were selected by the Environment Agency, in order to characterise the ecological value and sensitivity of those watercourses to potential impacts.

A first set of macroinvertebrate samples were collected in May 2016 by the Environment Agency. Additional macroinvertebrate sampling and specific freshwater mussel surveys were undertaken by AECOM in September 2016, as shown on the Table 2.1 below, which presents details of the sampling sites.

Table 2.1: Sampling sites description

Site Number	Watercourse	Site Name	NGR	Biosys Site ID	Macroinvertebrate survey	Mussel survey
1	Seacourt Stream	Upstream Seacourt Park and Ride	SP 49198 06580	184148	20/05/2016 14/09/2016	14/09/2016
2	Seacourt Stream	North Hinksey	SP 49463 05603	34452	20/05/2016 14/09/2016	14/09/2016
3	Bulstake Stream	Upstream Osney Mead Footbridge	SP 49838 05735	184149	20/05/2016 14/09/2016	14/09/2016
4	Hinksey Stream	Downstream Manor Farm Track	SP 50573 05116	184150	23/05/2016 15/09/2016	15/09/2016
5	Hogacre Ditch	Upstream Manor Farm Track	SP 50383 05202	184151	23/05/2016 15/09/2016	No mussel survey (dry)
6	Hinksey Stream	Upstream The Devil's Backbone Footbridge	SP 51182 04465	184152	23/05/2016 15/09/2016	15/09/2016
7	Eastwyke Ditch	Hinksey Park	SP 51475 04951	184153	23/05/2016 15/09/2016	15/09/2016
8	Chilswell Stream	Upstream Abingdon Road	SP 51594 03767	184154	23/05/2016 14/09/2016	No mussel survey
9	Hinksey Stream	Bypass Channel Upstream Abingdon Road	SP 51730 03939	184156	23/05/2016 14/09/2016	14/09/2016
10	Kennington Pit	Kennington Pit	SP 51868 03388	184157	23/05/2016 16/09/2016	No mussel survey
11	Weirs Mill Stream	80 m Upstream Southern Bypass	SP 52187 03538	184159	23/05/2016 15/09/2016	15/09/2016
12	River Thames	Fiddler's Elbow, Sandford	SP 52856 01785	184146	23/05/2016 15/09/2016	15/09/2016
13	River Thames	Downstream Sandford Lock Bridge	SP 53062 01197	184145	23/05/2016 15/09/2016	15/09/2016

2.3 Macroinvertebrate Surveys

2.3.1 Macroinvertebrate sampling

Invertebrate sampling by two experienced aquatic biologists was undertaken at the 13 sites using either kick sampling or sweep sampling or medium weight dredge, depending on access, depth and substrate conditions, as recommended by the Environment Agency and as shown on the Table 2.2 below.

Table 2.2: Sampling methodology used for the macroinvertebrate surveys

Sampling method	Sites
Kick sampling	3, 4, 5, 6, 7, 9
Sweep sampling from the bank	1, 2, 8, 10
Medium weight dredge from the bank	11, 12, 13

The sampling method followed the standard Environment Agency methodology (Environment Agency, 2012) at all sites, except Kennington Pit (Site 10). For Kennington Pit, the sampling methodology was based on the Predictive System for Multimetrics (PSYM) protocols used for ponds (Pond Action, 2002).

As set out in Table 2-2, above, for the majority of sites, samples were taken using a standard Freshwater Biological Association (FBA) pattern pond net (mesh size: 1 mm). At these sites habitats were 'kick sampled' or 'sweep sampled' for three minutes followed by a one-minute hand search of larger substrates. However, at three sites, dredge sampling was carried out. Dredge samples were collected by throwing a medium-weight naturalist dredge (with a 1 mm mesh net) from the banks onto the bed of the watercourse and 'dredging' the substrate. At each site, a minimum of three dredge 'throws' were employed, to ensure an sufficient amount of material was collected, as per Environment Agency recommendations.

The samples collected were subsequently preserved in Industrial Methylated Spirits (IMS) for laboratory processing. However, any unionid mussels and crayfish found were removed from the samples before preservation. Photographs were taken of each of the 'removed' specimens.

2.3.2 Sample processing and macroinvertebrate identification

Detailed sorting of the entire samples was carried-out by AECOM taxonomists in the laboratory using stereo-microscopes (under low power) and appropriate identification keys in line with Environment Agency (2014) guidance. Macroinvertebrates were identified to 'mixed taxon level' (as described in Environment Agency, 2014), which is to species level (where practicable) for the majority of groups. However, while mixed taxon level analysis does not require species level identification for pea mussels of the genus *Pisidium* (genus level identification only is required for mixed taxon level identification), any specimens that were suspected of being the rare *Pisidium tenuilineatum* were carefully identified, as this is considered to be of particular conservation interest and is reported as being potentially present in the study area.

Several species are awaiting further identification and verification and these are indicated in the results tables in Section 3 of this report.

2.3.3 Data analysis

The invertebrate data were analysed using the following indexes:

- Biological Monitoring Working Party (BMWP) scores and Average Score Per Taxon (ASPT) values (Hawkes, 1997) - an explanation of BMWP scores and ASPT is provided as Appendix C, scores are derived based on the sensitivity of particular taxa (families) of invertebrates to organic pollution;

- Community Conservation Index (CCI) method (Chadd and Extence, 2004) – to assess the conversation value of the macroinvertebrate populations present and identify and unusual or rare species;
- Lotic-Invertebrate Index for Flow Evaluation (LIFE) method (Extence, Balbi and Chadd, 1999) – to assess the sensitivity of benthic macroinvertebrate communities to variable flows.

Detailed descriptions of these indices are presented in Appendices C to F.

2.4 Mussel Surveys

Ten sites were initially selected for freshwater mussel surveys by the Environment Agency, however sampling could only carried out at nine sites, because one site (Site 5, Hogacre Ditch) was largely dry at the time of the mussel survey (September 2016) and could not be sampled.

2.4.1 Sampling technique

In determining the survey technique, consideration was given to previous research and survey development for unionid mussel species (Aldridge, 2002; Aldridge, 2004; Killeen et al., 2004; Willing, 2005; Willing, 2006), as well as our knowledge of unionid biology and ecology and experience of invertebrate and mussel sampling. We also took into consideration the practicalities of surveying at each of the sample locations and health and safety risks of associated with different survey techniques.

Each site was surveyed along transects, using an adapted hand-net (as described below) or a medium-weight naturalist dredge, depending on substrate type and access conditions, as shown on the sites 11, 12 and 13 could only be surveyed using the medium weight dredge, as the water was too deep and/or dangerous in the margins to enter and could not been sampled from the banks using the adapted hand net.

Table 2.3 below. The adapted hand net was the preferred method and was used for the majority of sites. However, sites 11, 12 and 13 could only be surveyed using the medium weight dredge, as the water was too deep and/or dangerous in the margins to enter and could not been sampled from the banks using the adapted hand net.

Table 2.3: Sampling methodology used for the mussel surveys

Sampling method	Sites
Net transect	1, 2, 3, 4, 6, 7, 9
Medium weight dredge	11, 12, 13

The adapted hand net is based on a standard Freshwater Biology Association (FBA) hand net with a modified lower edge and an extended handle (Appendix B, Plate B16). The lower aperture edge is built with a series of blunt ‘forks’ to dig up to 30 cm into the sediment (sufficient to allow collection of the mussels) before being pushed horizontally to collect a standard sized sample. The net has a 3 mm mesh to allow passage of fine sediment.

Using this method, samples were collected along a series of transects (either from the bank or by wading within the channel itself, depending on site conditions). On each transect, samples were taken at regular intervals. Typically, ten samples were taken along each transect and between four and eight transects were completed at each mussel sample site (depending on access, depth of the water along transects and availability of suitable mussel habitat).

For the sites where the adapted hand net could not be used (due to very deep water in the margins), a medium weight dredge with a coarse mesh (3 mm, again, to allow passage of fine sediment) was used. Dredge samples were collected by throwing the dredge from the banks onto the bed of the watercourse (as far as possible from the bank) and pulling the dredge through the substrate. In order to gather a representative sample and sufficient numbers of freshwater mussels, a minimum of six dredge ‘throws’ of the dredge from the banks were made.

All of the sampling undertaken was non-destructive and all specimens were returned to the sediment at the sample location.

2.4.2 Unionid Identification and Measurement

Identification of bivalve specimens was undertaken using appropriate keys (particularly Killeen et al., 2004). The shell length of the specimen collected was also measured.

All identification and measurement was undertaken on the bankside immediately following collection before returning the mussels to the river. Photographs of the specimens were taken and no unioinids were retained.

3. Results

3.1 Site Descriptions

Summary descriptions of the habitats and other relevant features associated with each of the sample sites are provided in Table 2.1.

Table 3.1: Description of the sampling sites

Site	Watercourse	Description
Site 1	Seacourt Stream	Tributary of Hinksey Stream. Pool habitat, approximately 6 m wide and 50 cm deep, slow flowing (<10cm/sec), with a substrate comprising gravel (20%), sand (30%) and silt (50%). Channel heavily shaded by riparian vegetation. Surrounding land use of broadleaf woodland, roads / railway within urban development. Appendix B, Plate B1.
Site 2		Tributary of Hinksey Stream. Pool habitat, approximately 6 m wide and 70 cm deep, slow flowing (<10 cm/sec), with a substrate dominated by sand (10%) and silt (90%). Channel lightly shaded by riparian vegetation. Surrounding land use of broadleaf woodland, scrub, improved pasture, roads / railway. Appendix B, Plate B2.
Site 3	Bulstake Stream	Tributary of the River Thames. Riffle / run habitat, approximately 6 m wide and 50 cm deep, and moderately fast flowing (25 to 50 cm/sec), substrate comprised cobbles (10%), pebbles (30%), gravel (30%), sand (20%) and silt (10%). Channel lightly shaded by riparian vegetation, including widespread himalayan balsam (*Impatiens glandulifera*). Surrounding land use of road / railway. Appendix B, Plate B3.
Site 4	Hinksey Stream	Hinksey Stream, upstream stretch. Glide habitat, approximately 6 to 8 m wide and 80 cm to > 1m deep, slow flowing (< 10 cm/sec), with a substrate comprising pebbles (10%), gravel (30%), sand (30%) and silt (10%). Presence of macrophytes (*Sparganium erectum*, *Lemna* sp., *Lythrum* sp.). Channel moderately shaded. Surrounding land use of broadleaf woodland, with improved pasture and farm buildings. Appendix B, Plate B4.
Site 5	Hogacre Ditch	Tributary of Hinksey Stream. Ditch habitat, approximately 1 m wide and < 2 cm deep, slow flowing (< 10 cm/sec), with a substrate dominated by silt (100%). Heavily shaded and overgrown channel, almost dry at the time of the September 2016 survey. Surrounding land use of broadleaf woodland, with improved pasture and farm buildings. Appendix B, Plate B5.
Site 6	Hinksey Stream	Hinksey Stream, mid-reach. Glide habitat, approximately 6 to 8 m wide and 50 cm to 60 cm deep, slow flowing (< 10 cm/sec), substrate comprised pebbles (20%), gravel (30%), sand (30%) and silt (20%). Presence of macrophytes (*Schoenoplectus lacustris*, *Glyceria maxima*, *Callitriche* sp., *Elodea nutalii*). Channel moderately shaded. Surrounding land use of broadleaf woodland, with improved pasture and farm buildings. Appendix B, Plate B6.
Site 7	Eastwyke Ditch	Tributary of the River Thames. Ditch habitat, approximately 4 m wide and 60 cm deep, slow flowing (<10cm/sec), with a substrate comprising pebbles (30%), gravel (30%), sand (30%) and silt (20%). Moderately shaded channel. Surrounding land use of road / railway, within urban area. Appendix B, Plate B7.
Site 8	Chiswell Stream	Tributary of Hinksey Stream. Pool habitat, approximately 2 m and 50 cm deep, slow flowing (< 10 cm/sec), with a substrate dominated by silt (100%). Presence of macrophytes (*Glyceria maxima*, *Lemna minor*, *Callitriche* sp., *Mentha aquatica*). Heavily shaded channel. Surrounding land use of broadleaf woodland, improved pasture and road / railway. Appendix B, Plate B8.
Site 9	Hinksey Stream	Hinksey Stream, downstream stretch. Glide habitat, approximately 6 to 8 m wide and 30 cm to 60 cm deep, moderately fast flowing (10 to 25 cm/sec), with a substrate comprising boulders/cobbles (20%), pebbles (30%), gravel (30%), sand (10%) and silt (10%). Channel heavily shaded by riparian vegetation. Surrounding land use of broadleaf woodland, industrial buildings and road / railway. Appendix B, Plate B9.

Site	Watercourse	Description
Site 10	Kennington Pit	Tributary of Hinksey Stream. Pond habitat, 50 cm deep, slow flowing (< 10 cm/sec), with a substrate consituted of gravel (20%), sand (10%) and silt (70%). Presence of macrophytes (*Lemna trisulca, Phalaris arundinacea, Carex sp., Typha latifloia, Mentha aquatica*) Moderately shaded by riparian vegetation. Surrounded land use of broadleaf woodland, with road / railway within urban area. Appendix B, Plate B10.
Site 11	Weirs Mill Stream	Tributary of Hinksey Stream. Glide habitat, approximately 25 m wide and > 1 m deep, slow flowing (<10cm/sec), with a substrate comprising gravel (15%), sand (15%) and silt/clay (70%). Channel lighlty shaded by riparian vegetation, including the non-native Himalayan balsam (*Impatiens glandulifera*). Presence of macrophytes (*Glyceria maxima, Phragmites australis*). Surrounding land use of broadleaf woodland, rough pasture and road / railway. Appendix B, Plate B11.
Site 12	River Thames	River Thames. Glide habitat, approximately 20 m and > 1 m deep, slow flowing (< 10 cm/sec), with a substrate comprising gravel (15%), sand (10%) and silt/clay (75%). Channel lightly shaded by riparian vegetation. Presence of macrophytes (*Carex* sp., *Phargmites australis*). Surrounding land use of scrub, improved pasture and road / railway. Appendix B, Plate B12.
Site 13		River Thames. Glide habitat, approximately 30 m and > 1 m deep, slow flowing (<10cm/sec), with a substrate of pebbles (15%), gravel (35%) and silt (50%). Surrounding land use of broadleaf woodland, park and road / railway. Appendix B, Plate B13.

3.2 Macroinvertebrate Surveys

The results of the macroinvertebrate surveys are presented in the following section. The results are grouped by watercourse, in order to help show if there are any upstream or downstream trends or relationships between nearby sites.

3.2.1 Seacourt Stream (Site 1 – 184148 and Site 2 - 34452)

Table 3.2 below presents the results of the macroinvertebrate analyses undertaken in May and September 2016 in Seacourt Stream.

Table 3.2: Macroinvertebrate taxa list for Seacourt Stream

BMWP group	Species	BMWP score	Conservation Score	Flow group	Site 1 (184148)		Site 2 (34452)	
					May-16	Sep-16	May-16	Sep-16
Snails								
Hydrobiidae	*Potamopyrgus antipodarum*	**3**	**1**	**III**	6	6	9	20
Physidae	*Physa fontinalis*		**1**	**III**	2	2	16	10
Planorbidae	Species to be confirmed	**3**				1		
Limpets and mussels								
Ancylidae grp.	*Ancylius fluviatilis*	**6**	**1**	**II**	1			
	Acroloxus lacustris		**2**			6	3	
Sphaeriidae	*Pisidium sp.*	**3**			22	23	13	6
	Pisidium species to be confirmed				1	2		3
Unionidae	*Unio tumidus*	**6**	**5**	**III**		2		
Worms								
Oligochaeta		**1**			65	11	108	
Leeches								
Piscicolidae	*Piscicola sp.*	**4**		**II**			1	1
Crustaceans								
Cladocera		**-**					19	
Gammaridae	*Gammarus pulex*	**6**	**1**	**II**	35	12		

BMWP group	Species	BMWP score	Conservation Score	Flow group	Site 1 (184148)		Site 2 (34452)	
					May-16	Sep-16	May-16	Sep-16
	Dikerogammarus haemobaphes					9	35	4
Crangonyctidae	*Crangonyx pseudogracilis*	**6**	**1**	**III**	70	20	180	26
Corophidae	Corophidae (juvenile / damaged)	**6**						
	Corophium curvispinum		**3**	**III**	5	9		
Crayfish	Species to be confirmed				2			
Asellidae	*Asellus aquaticus*		**1**	**IV**	5	6	26	2
Mayflies								
Baetidae	Baetidae (juvenile / damaged)	**4**		**II**			3	
	Baetis sp.				3			
	Baetis rhodani		**1**	**II**	1			
Ephemerellidae	*Serratella ignita*	**10**	**1**	**II**	1			
Ephemeridae	*Ephemera sp.*	**10**					1	1
	Ephemera danica		**1**	**II**	1	7		
	Ephemera vulgata		**4**	**III**			2	
Caenidae	*Caenis sp.*	**7**				1		
	Caenis macrura		**4**	**III**			1	
Damselflies								
Calopterygidae	*Calopteryx sp.*	**8**				1		
	Calopteryx splendens		**2**	**III**	2	2	1	
True bugs								
Gerridae	Gerridae (nymph / damaged)	**5**		**IV**				1
	Gerris lacustris		**1**			2		1
Corixidae	*Sigara falleni*	**5**	**1**	**IV**				
	Sigara nigrolineata		**2**	**IV**			1	
Notonectidae	*Notonecta glauca*	**5**	**1**	**IV**				2
Beetles								
Gyrinidae	Gyrinidae (larvae / damaged)	**5**		**IV**			2	
Alderflies								
Sialidae	*Sialis lutaria*	**4**	**1**	**IV**		12		1
Caddisflies								
Polycentropodidae	Polycentropodidae (juvenile / damaged)	**7**		**IV**		1		
	Polycentropus irroratus		**5**	**II**	5		1	2
	Holocentropus dubius		**4**	**V**		1		
	Holocentropus picicornis		**3**	**V**				1
	Cyrnus trimaculatus		**3**	**IV**			1	
Psychomyiidae	*Lype reducta*	**8**	**3**	**II**	1	1		
Hydroptilidae	*Hydroptila sp.*	**6**			1		1	
Leptoceridae	*Ceraclea dissimilis*	**10**	**3**	**IV**			2	
	Mystacides longicornis		**1**	**IV**		1		1
Brachycentridae	*Brachycentrus subnubilus*	**10**	**6**	**II**		1		
Trueflies								
Chironomidae	Chironomidae (damaged)	**2**			4		2	
	Tanypodinae				20	13	30	
	Orthocladiinae				35	7	160	
	Chironomini				35	26	260	7
	Tanytarsini				180	3		
	Prodiamesinae					13		3
Dixidae	*Dixa nebulosa*	**-**	**4**			1		
Empididae	Empididae	**-**			2			

BMWP group	Species	BMWP score	Conservation Score	Flow group	Site 1 (184148)		Site 2 (34452)	
					May-16	Sep-16	May-16	Sep-16
Other Taxa								
Lepidoptera		-				1		
Number of scoring families					**16**	**20**	**18**	**13**
Number of non-scoring families					**1**	**2**	**1**	**0**
Total number of families					**17**	**22**	**19**	**13**
BMWP score					**86**	**111**	**93**	**65**
ASPT					**5.4**	**5.6**	**5.2**	**5.0**
LIFE Score					**7.5**	**6.8**	**6.8**	**6.5**
CCI Score					**8.5**	**11.2**	**12.1**	**8.0**

The results from the samples taken on Seacourt Stream indicate that the stream is of good to very good biological quality (BMWP scores 65 to 111, ASPT 5.0 to 5.2), with samples characterised by a moderate to high diversity of taxa (13 to 22 families recorded) and the presence of taxa considered to be sensitive to pollution, including the highly pollution sensitive *Serratella ignita*, *Ephemera vulgata*, *Ephemera danica* (mayfly larvae), *Brachycentrus subnubilus*, *Ceraclea dissimilis* and *Mystacides longicornis* (caddisfly larvae).

In terms of flow sensitivity, the samples comprise taxa that are typical of rapid to fast flowing conditions (flow groups I and II), such as *Ancylus fluvialtilis* and *Serratella ignita*, as well as other species adapted to slower flows (flow groups III and IV), such as true bugs (Corixidae, Gerridae). Species typical of faster flows were more represented at Site 1 (especially in May 2016) than at Site 2, as shown by the relatively high LIFE score (7.8) at Site 1 for May 2016 and moderate (6.5 to 6.8) at Site 1 in September and Site 2.

Most of the species that were recorded are common, with the notable exception of the caddisfly larvae *Brachycentrus subnubilus* (Conservation Score 6, 'Regionally Notable'), the mussel *Unio tumidus* at Site 1 and the caddisfly larvae *Polycentropus irroratus* (Conservation Score 5, 'Notable') at both sites. This is reflected in the CCI scores, indicative of 'Moderate' to 'Fairly High' conservation value (8.0 to 12.1).

3.2.2 Bulstake Stream (Site 3 - 184149)

Table 3.3 below presents the results of the macroinvertebrate analyses undertaken in May and September 2016 in Bulstake Stream.

Table 3.3: Macroinvertebrate taxa list for Bulstake Stream

BMWP group	Species	BMWP score	Conservation Score	Flow group	Site 3 (184149)	
					May-16	Sep-16
Snails						
Hydrobiidae	*Potamopyrgus antipodarum*	**3**	**1**	**III**	15	12
Physidae	*Physa heterostropha*	**3**				2
Limpets and mussels						
Ancylidae grp.	*Ancylius fluviatilis*	**6**	**1**	**II**	1	15
	Acroloxus lacustris		**2**			15
Sphaeriidae	*Sphaerium sp.*	**3**			1	
	Sphaerium rivicola		**3**	**III**		5
	Pisidium sp.				8	
Worms						
Oligochaeta		**1**			80	18
Crustaceans						
Gammaridae	*Dikerogammarus haemobaphes*	**6**			15	16

BMWP group	Species	BMWP score	Conservation Score	Flow group	Site 3 (184149)	
					May-16	Sep-16
Crangonyctidae	*Crangonyx pseudogracilis*	**6**	**1**	**III**	8	
Corophidae	*Corophium curvispinum*	**6**	**3**	**III**	17	80
Astacidae	*Pacifastacus leniusculus*	**8**			1	
Asellidae	*Asellus aquaticus*	**3**	**1**	**IV**		1
Mayflies						
Baetidae	Baetidae (juvenile / damaged)	**4**		**II**	1	1
Ephemerellidae	*Serratella ignita*	**10**	**1**	**II**	2	
Ephemeridae	*Ephemera sp.*	**10**				1
	Ephemera danica		**1**	**II**	1	2
	Ephemera vulgata		**4**	**III**	20	
Caenidae	*Caenis sp.*	**7**				1
	Caenis robusta		**5**	**IV**	40	
Damselflies						
Calopterygidae	*Calopteryx splendens*	**8**	**2**	**III**		4
True bugs						
Gerridae	Gerridae (nymph / damaged)	**5**		**IV**		1
Alderflies						
Sialidae	*Sialis lutaria*	**4**	**1**	**IV**		1
Caddisflies						
Rhyacophilidae	*Rhyacophila dorsalis*	**7**	**1**	**I**		1
Hydroptilidae	*Hydroptila sp.*	**6**				1
Limnephilidae	*Anabolia nervosa*	**7**	**2**	**IV**	1	
Leptoceridae	*Athripsodes sp.*	**10**				3
	Mystacides longicornis		**1**	**IV**		1
Goeridae	*Goera pilosa*	**10**	**3**	**I**		3
Trueflies						
Chironomidae	Tanypodinae	**2**				4
	Chironomini				20	16
	Tanytarsini				30	40
	Prodiamesinae					4
Simuliidae	Simuliidae (damaged / juvenile)	**5**		**II**	10	1
	Simulium ornatum group		**1**		5	
Dixidae	*Dixa nebulosa*	**-**	**4**			1
Number of scoring families					**13**	**20**
Number of non-scoring families					**0**	**1**
Total number of families					**13**	**21**
BMWP score					**78**	**109**
ASPT					**6.0**	**5.5**
LIFE Score					**7.3**	**7.4**
CCI Score					**10.0**	**8.8**

The results above indicate that Bulstake Stream is of good biological quality (BMWP scores 78 to 109, ASPT 5.5 to 6.0), with samples characterised by a moderate diversity (13 to 21 families recorded) and the presence of a several taxa considered to be highly sensitive to pollution, such as *Goera pilosa*, *Mystacides longicornis*, *Athripsodes* sp. (caddisfly larvae), *Ephemera danica*, *Ephemera vulgata* and *Serratella ignita* (mayfly larvae).

The samples comprise taxa typical of rapid to fast flowing conditions (flow groups I and II), such as *Rhyacophila dorsalis* and *Goera pilosa* and species adapted to slower flows (flow groups III and IV), such as alderflies (*Sialis lutaria*) and true bugs (Gerridae). The presence of species likely to be sensitive to flow reductions is reflected in the relatively high LIFE scores (7.3 and 7.4).

In terms of conservation value, all species recorded are common, with the notable exception of the mayfly larvae *Caenis robusta (*Conservation Score 5, 'Local'), as shown by the CCI scores indicative of a Moderate conservation value.

3.2.3 Hinksey Stream (Site 4 - 184150, Site 6 - 184152 and Site 9 -- 184156)

Table 3.4 below presents the results of the macroinvertebrate analyses undertaken in May and September 2016 in Hinksey Stream.

Table 3.4: Macroinvertebrate taxa list for Hinksey Stream

BMWP group	Species	BMWP score	Conservation Score	Flow group	Site 4 (184150)		Site 6 (184152)		Site 9 (184156)	
					May-16	Sep-16	May-16	Sep-16	May-16	Sep-16
Snails										
Viviparidae	*Viviparus fasciatus*	**6**		**III**						15
Valvatidae	*Valvata cristata*	**3**	**2**	**IV**			5			
Hydrobiidae	*Potamopyrgus antipodarum*	**3**	**1**	**III**	50	83	370	50	50	
Physidae	*Physa heterostropha*	**3**								1
	Physa fontinalis		**1**	**III**		33		11		
Planorbidae	Species to be confirmed	**3**						1		
	Gyraulus laevis		**6**	**V**					2	
	Gyraulus albus		**1**	**IV**			3	3		
Limpets and mussels										
Ancylidae grp.	*Ancylius fluviatilis*	**6**	**1**	**II**			1			
	Acroloxus lacustris		**2**		3	12		4		1
Sphaeriidae	*Sphaerium sp.*	**3**							8	
	Sphaerium corneum		**1**	**IV**					2	
	Pisidium sp.				4	38	19	6	81	2
	Pisidium species to be confirmed							1		
	Musculium sp.							1		
Unionidae	*Unio tumidus*	**6**	**5**	**III**				1		
Worms										
Oligochaeta		**1**			30	3	90	12	22	25
Leeches										
Erpobdellidae	*Erpobdella sp.*									1
Crustaceans										
Mysidae		**-**		**V**			2	1		
Gammaridae grp	*Gammarus sp.*	**6**					2			
	Gammarus pulex		**1**	**II**	40	15				
	Dikerogammarus haemobaphes				10	5	6	18	145	10
Crangonyctidae	*Crangonyx pseudogracilis*	**6**	**1**	**III**	80	95	1	22	78	1
Crayfish	Species to be confirmed						5		1	1
Astacidae	*Pacifastacus leniusculus*	**8**				1		1		
Asellidae	*Asellus aquaticus*	**3**	**1**	**IV**	18	8	30	11	66	
	Asellus meridianus		**3**	**IV**		2				
Mayflies										
Baetidae	Baetidae (juvenile / damaged)	**4**		**II**		1	1		9	
	Baetis sp.				30					
Ephemerellidae	*Serratella ignita*	**10**	**1**	**II**	1					
Ephemeridae	*Ephemera danica*	**10**	**1**	**II**					12	
	Ephemera vulgata		**4**	**III**	50	3			1	
Caenidae	*Caenis sp.*	**7**							5	

BMWP group	Species	BMWP score	Conservation Score	Flow group	Site 4 (184150)		Site 6 (184152)		Site 9 (184156)	
					May-16	Sep-16	May-16	Sep-16	May-16	Sep-16
	Caenis luctuosa		**1**	**IV**					3	
	Caenis robusta		**5**	**IV**					2	
True bugs										
Gerridae	Gerridae (nymph / damaged)	**5**		**IV**		1				
	Gerris lacustris		**1**			2				
Corixidae	*Sigara falleni*	**5**	**1**	**IV**				1		
Notonectidae	*Notonecta glauca*	**5**	**1**	**IV**				2		
Beetles										
Haliplidae	Haliplidae (larvae / damaged)	**5**		**IV**	1					
Gyrinidae	Gyrinidae (larvae / damaged)	**5**		**IV**		3				
Dytiscidae group	Dytiscidae (larvae / damaged)	**5**		**IV**		3				
Hydrophilidae group	*Hydraena riparia*	**5**	**1**	**IV**		1				
Scirtidae	Scirtidae (larvae / damaged)	**5**		**IV**						
Alderflies										
Sialidae	*Sialis lutaria*	**4**	**1**	**IV**		5		2		
Caddisflies										
Polycentropodidae	Polycentropodidae (juvenile / damaged)	**7**		**IV**		4				1
	Cyrnus trimaculatus		**3**	**IV**	1					
Psychomyiidae	*Lype reducta*	**8**	**3**	**II**		2				2
Hydropsychidae	*Hydropsyche angustipennis*	**5**	**1**	**II**					1	
Hydroptilidae	*Hydroptila sp.*	**6**			1					
Limnephilidae	*Limnephilus lunatus*	**7**	**1**	**IV**			1		1	
Leptoceridae	*Athripsodes sp.*	**10**			1			3		
	Mystacides longicornis		**1**	**IV**		2	1			
Goeridae	*Goera pilosa*	**10**	**3**	**I**		1				1
Trueflies										
Chironomidae	Chironomidae (damaged)	**2**				6		1	8	2
	Tanypodinae				25	4	90	7	150	
	Orthocladiinae				12	36	20		300	15
	Chironomini						150	22	400	10
	Tanytarsini				35	44	100	12	650	22
	Prodiamesinae					12		10	70	30
Tipulidae group	Tipulidae	**5**		**IV**			1			
Simuliidae	Simuliidae (damaged / juvenile)	**5**		**II**		3				
	Simulium erythrocephalum		**3**		40					
Dixidae	Dixidae (damaged / juvenile)	**-**						1		
	Dixa nebulosa		**4**			3		2		
Empididae		**-**							1	
Other Taxa										
Lepidoptera		**-**				3				
Number of scoring families					**15**	**20**	**13**	**14**	**12**	**11**
Number of non-scoring families					**0**	**2**	**1**	**2**	**1**	**0**
Total number of families					**15**	**22**	**14**	**16**	**13**	**11**
BMWP score					**81**	**113**	**56**	**68**	**54**	**55**
ASPT					**5.4**	**5.7**	**4.3**	**4.9**	**4.5**	**5.0**
LIFE Score					**6.9**	**6.9**	**6.4**	**6.1**	**6.7**	**7.4**
CCI Score					**5.7**	**9.3**	**3.4**	**8.6**	**11.0**	**6.8**

The data set out in Table 3.4, above, indicate that Hinskey Stream is of good biological quality in its most upstream stretch, at Site 4 (BMWP scores 81 to 113, ASPT 5.4 to 5.7). At Site 4, samples were characterised by a moderate to relatively high diversity (15 to 22 families recorded) and the presence of several taxa that are considered as being highly sensitive to pollution, such as *Goera pilosa*, *Mystacides longicornis* (caddisfly larvae), *Ephemera vulgata* and *Serratella ignita* (mayfly larvae).

For the most downstream sites (Site 6 and Site 9), the biotic indices (BMWP scores 55 to 68, ASPT 4.3 to 5.0) are indicative of a moderate biological quality, although several highly pollution sensitive caddisfly larvae and mayfly larvae were still recorded. In addition, abundances of Chironomidae, which are usually considered as being pollution tolerant, were higher at those sites than at Site 4. This may signify a difference in water quality (presence of organic pollution, such as sewage) between the sites.

In terms of flow sensitivity, the samples were dominated by taxa that are typical of slow flowing and/or standing conditions (flow groups III, IV), although several taxa which are typical of rapid and fast flows (flow groups I and II) were also recorded, essentially at the most upstream site, Site 4 (*Goera pilosa,* Simuliidae) and the most downstream site, Site 9 (*Lype reducta*, *Goera pilosa*). This is reflected by the low LIFE scores (5.6 to 6.3).

All of the species recorded are very common, with the exception of the snail *Gyraulus laevis* at Site 9 (Conservation Score 6, 'Regionally Notable'), the mussel *Unio tumidus* at Site 6 (Conservation Score 5, Notable) and the mayfly *Caenis robusta* at Site 9 (Conservation Score 5, 'Notable'). This is also demonstrated by the CCI scores, which are indicative of a moderate to 'Fairly High' (Site 9, May) conservation value.

3.2.4 Hogacre Ditch (Site 5 - 184151)

Table 3.2, below, presents the results of the macroinvertebrate analyses undertaken in May and September 2016 on Hogacre Ditch.

Table 3.5: Macroinvertebrate taxa list for Hogacre Ditch

BMWP group	Species	BMWP score	Conservation Score	Flow group	Site 5 (184151)	
					May-16	Sep-16
Flatworms					1	
Snails						
Physidae	*Physa heterostropha*	**3**				6
	Physa fontinalis		**1**	**III**	1	
Succinea	*Succinea sp.*	**-**			1	
Limpets and mussels						
Sphaeriidae	*Pisidium sp.*	**3**			14	
Worms						
Oligochaeta		**1**			305	70
Crustaceans						
Cladocera		**-**			57	
Crangonyctidae	*Crangonyx pseudogracilis*	**6**	**1**	**III**	11	
Asellidae	*Asellus aquaticus*	**3**	**1**	**IV**	640	5
Dytiscidae group	Dytiscidae (larvae / damaged)	**5**		**IV**	3	
Hydrophilidae group	*Helophorus sp.*	**5**			2	
	Helophorus brevipalpis		**1**	**IV**	1	
Scirtidae	Scirtidae (larvae / damaged)	**5**		**IV**	1	
Trueflies						
Chironomidae	Chironomidae (damaged)	**2**				8
	Tanypodinae				21	
	Orthocladiinae				205	
	Chironomini				243	

BMWP group	Species	BMWP score	Conservation Score	Flow group	Site 5 (184151)	
					May-16	Sep-16
Dixidae	*Dixa nebulosa*	-	4			1
Psychodidae		-				8
Empididae		-			1	
Syrphidae		-				2
Culicidae	Culicidae	-		V		5
Other Taxa						
Lepidoptera		-			2	
Number of scoring families					**9**	**4**
Number of non-scoring families					**4**	**4**
Total number of families					**13**	**8**
BMWP score					**33**	**9**
ASPT					**3.7**	**2.3**
LIFE Score					**6.0**	**5.5**
CCI Score					**1.0**	**7.5**

The results above indicate that Hogacre Ditch is of poor biological quality (BMWP scores 9 to 33, ASPT 2.3 to 3.7), with samples characterised by a low diversity (8 to 13 families recorded) and the lack of pollution sensitive taxa. Samples were dominated by pollution tolerant taxa, such as crustaceans (Asellidae), worms (Oligochaeta) and truefly larvae (Chironomidae).

In terms of flow sensitivity, the communities exclusively comprise species adapted to slow flowing / standing conditions (Flow groups III, IV and V), as reflected by the low LIFE scores (5.5 to 6.0).

All species recorded are common, as shown by the CCI scores indicate of a 'Low' to 'Moderate' conservation value.

3.2.5 Eastwyke Ditch (Site 7 - 184153)

Table 3.6 below presents the results of the macroinvertebrate analyses undertaken in May and September 2016 in Eastwyke Ditch.

Table 3.6: Macroinvertebrate taxa list for Eastwyke Ditch

BMWP group	Species	BMWP score	Conservation Score	Flow group	Site 7 (184153)	
					May-16	Sep-16
Flatworms						
Dugesiidae	*Dugesia sp.*				1	
Snails						
Hydrobiidae	*Potamopyrgus antipodarum*	**3**	**1**	**III**	136	76
Bithyniidae	*Bithynia tentaculata*	**-**	**1**	**IV**	5	
Physidae	*Physa fontinalis*	**3**	**1**	**III**	75	38
Planorbidae	*Gyraulus albus*	**3**	**1**	**IV**	2	1
	Hippeutis complanatus		**3**	**V**		1
Limpets and mussels						
Ancylidae grp.	*Acroloxus lacustris*	**6**	**2**		3	3
Sphaeriidae	*Pisidium sp.*	**3**			91	50
	Musculium sp.					4
Worms						
Oligochaeta		**1**			68	11
Leeches						
Glossiphoniidae	*Helobdella stagnalis*	**3**	**1**	**IV**	2	
Piscicolidae	*Piscicola sp.*	**4**		**II**	1	
Crustaceans						
Ostracoda		**-**				1

BMWP group	Species	BMWP score	Conservation Score	Flow group	Site 7 (184153)	
					May-16	Sep-16
Cladocera		-			120	
Mysidae		-		V		2
Gammaridae grp	*Gammarus sp.*	6			2	
	Dikerogammarus haemobaphes				3	10
Crangonyctidae	*Crangonyx pseudogracilis*	6	1	III	101	5
Crayfish	Species to be confirmed				4	
Astacidae	*Pacifastacus leniusculus*	8				1
Asellidae	*Asellus aquaticus*	3	1	IV	310	50
Damselflies						
Coenagrionidae	*Coenagrion sp.*	6				1
True bugs						
Veliidae	Veliidae (nymph / damaged)	-		IV	1	
Notonectidae	Notonectidae (nymph / damaged)	5		IV	1	
Beetles						
Dytiscidae group	Dytiscidae (larvae / damaged)	5		IV	1	
Caddisflies						
Limnephilidae	*Limnephilus lunatus*	7	1	IV	1	
Leptoceridae	*Athripsodes cinereus*	10	1	II	1	
	Mystacides sp.				2	
	Mystacides longicornis		1	IV	5	6
Trueflies						
Chironomidae	Chironomidae (damaged)	2				1
	Tanypodinae					10
	Orthocladiinae				52	
	Chironomini				518	130
Tipulidae group	Limoniidae	5			1	
Stratiomyidae	*Oxycera pygmaea*	-	7		1	
Other Taxa						
Lepidoptera		-				1
Number of scoring families					**17**	**11**
Number of non-scoring families					**3**	**3**
Total number of families					**20**	**14**
BMWP score					**74**	**54**
ASPT					**4.4**	**4.9**
LIFE Score					**6.4**	**6.0**
CCI Score					**11.1**	**4.1**

The results in Table 3-6, above, indicate that Eastwyke Ditch is of moderate biological quality (BMWP scores 54 to 74, ASPT 4.4 to 4.9). The samples are characterised by a moderate diversity (14 to 20 families recorded) and a lack of pollution sensitive taxa, with the exception of *Athripsodes cinereus* and *Mystacides longicornis* (caddisfly larvae), which are considered as being highly pollution sensitive.

The communities are largely dominated by taxa that are typical slow flowing or standing conditions (flow groups III and IV), such as true bugs (Velidae, Notonectidae) and snails (*Potamopyrgus antipodarum, Bithynia tentaculata, Physa fontinalis, Gyraulus albus and Hippeutis complanatus*), as reflected in the relatively low LIFE scores (6.0 to 6.4).

In terms of conservation value, all species recorded are very common, with the exception of the soldierfly *Oxycera pygmaea (*Conservation Score 7, 'Notable' but not RDB status) in May 2016, as shown by the CCI score indicative of a 'Fairly High' conservation value for the sample taken in May 2016, but 'Low' in September 2016.

3.2.6 Chiswell Stream (Site 8 - 184154)

Table 3.7 below presents the results of the macroinvertebrate analyses undertaken in May and September 2016 in Chiswell Stream.

Table 3.7: Macroinvertebrate taxa list for Chiswell Stream

BMWP group	Species	BMWP score	Conservation Score	Flow group	Site 8 (184154)	
					May-16	Sep-16
Flatworms						
Dugesiidae	*Dugesia lugubris/polychroa*		**2**	**IV**	3	
Snails						
Lymnaeidae	*Stagnicola palustris*	**3**	**2**	**VI**		2
	Radix balthica		**1**	**IV**	1	
Valvatidae	*Valvata cristata*	**3**	**2**	**IV**	38	32
	Valvata piscinalis		**1**	**IV**		3
Succinea	*Succinea sp.*	**-**			1	
Planorbidae	*Planorbis planorbis*	**3**	**1**	**IV**		40
	Anisus vortex		**1**	**IV**	2	8
Limpets and mussels						
Ancylidae grp.	*Acroloxus lacustris*	**6**	**2**		30	
Sphaeriidae	*Pisidium sp.*	**3**			111	30
	Pisidium species to be confirmed					1
Worms						
Oligochaeta		**1**			18	
Crustaceans						
Copepoda		**-**			20	
Cladocera		**-**			65	
Gammaridae	*Gammarus pulex*	**6**	**1**	**II**	10	
Crangonyctidae	*Crangonyx pseudogracilis*	**6**	**1**	**III**	50	208
Asellidae	*Asellus aquaticus*		**1**	**IV**	285	845
Mayflies						
Baetidae	Baetidae (juvenile / damaged)	**4**		**II**	1	
	Baetis rhodani		**1**	**II**	1	
Leptophlebiidae	Leptophlebiidae (juvenile / damaged)	**10**		**II**	2	
True bugs						
Notonectidae	*Notonecta glauca*	**5**	**1**	**IV**	1	
Beetles						
Haliplidae	*Haliplus lineaticollis*		**1**	**III**		2
Dytiscidae group	Dytiscidae (larvae / damaged)	**5**		**IV**		3
	Agabus bipustulatus		**1**	**IV**		1
	Ilybius fuliginosus		**1**	**IV**		1
	Ilybius quadriguttatus		**5**	**V**		1
	Dytiscus marginalis		**1**	**IV**		1
Hydrophilidae grp.	*Helophorus brevipalpis*	**5**	**1**	**IV**	4	
	Anacaena limbata		**1**	**IV**		1
Hydraenidae	*Ochthebius sp.*					2
Alderflies						
Sialidae	*Sialis lutaria*	**4**	**1**	**IV**		14
Caddisflies						
Limnephilidae	Limnephilidae (juvenile / damaged)	**7**		**IV**	2	
	Limnephilus marmoratus		**3**	**V**	1	
	Limnephilus lunatus		**1**	**IV**	12	
Trueflies						
Chironomidae	Chironomidae (damaged)	**2**				3

BMWP group	Species	BMWP score	Conservation Score	Flow group	Site 8 (184154)	
					May-16	Sep-16
	Tanypodinae				10	
	Orthocladiinae				50	
	Chironomini					
	Tanytarsini				300	2
Dixidae	Dixidae (damaged / juvenile)	-				2
	Dixella sp.					1
Empididae		-			2	
Stratiomyidae	*Oxycera* sp.					2
Culicidae	Culicidae	-		V		1
Number of scoring families					**15**	**11**
Number of non-scoring families					**4**	**3**
Total number of families					**19**	**14**
BMWP score					**66**	**42**
ASPT					**4.4**	**3.8**
LIFE Score					**6.3**	**5.6**
CCI Score					**4.2**	**7.1**

The results presented in Table 3.7, above, indicate that Chiswell Stream is of moderate biological quality (BMWP scores 42 to 64, ASPT 3.8 to 4.4). The samples are characterised by a moderate diversity of invertebrates (14 to 19 families recorded) and a lack of pollution sensitive taxa, with the exception of 2 Leptophlebiidae specimens (mayfly larvae) and the caddisfly larvae *Limephilus marmoratus* and *Limnephilus lunatus* in May 2016. The most abundant taxa were crustaceans (*Asellus aquaticus*, *Crangonyx pseudogracilis*) and truefly larvae (Chironomidae).

Most of the taxa recorded are typical of slow flowing / standing conditions (flow groups III, IV), with the exception of the crustacean *Gammarus pulex* and the mayflies Leptophlebiidae and *Baetis rhodani* (flow group II). This is reflected by the low LIFE scores (5.6 to 6.3).

In terms of conservation value, all species recorded are common, with the exception of the diving beetle *Ilybius quadriguttatus* (Conservation Score 5, 'Local'), as shown by the CCI scores, which are indicative of 'Low' to 'Moderate' conservation value.

3.2.7 Kennington Pit (Site 10 - 184157)

Table 3.8 below shows the results of the macroinvertebrate analyses undertaken in May and September 2016 in Kennington Pit.

Table 3.8: Macroinvertebrate taxa list for Kennington Pit

BMWP group	Species	BMWP score	CS	Flow group	Site 10 (184157)	
					May-16	Sep-16
Flatworms						
Dugesiidae	*Dugesia sp.*				1	
	Dugesia lugubris/polychroa		**2**	**IV**		1
Snails						
Viviparidae	*Viviparus fasciatus*	**6**		**III**	2	1
Lymnaeidae	*Lymnaea stagnalis*	**3**	**1**	**IV**	3	1
	Radix auricularia		**2**	**IV**	1	
Valvatidae	*Valvata cristata*	**3**	**2**	**IV**	10	1
Hydrobiidae	*Potamopyrgus antipodarum*	**3**	**1**	**III**		1
Bithyniidae	*Bithynia tentaculata*		**1**	**IV**	45	10
	Bithynia leachi		**5**	**IV**		25
Physidae	*Physa fontinalis*	**3**	**1**	**III**	7	8
Succinea	*Succinea sp.*	**-**				1

BMWP group	Species	BMWP score	CS	Flow group	Site 10 (184157)	
					May-16	Sep-16
Planorbidae	*Planorbarius corneus*	**3**	**4**	**IV**	3	4
	Planorbis planorbis		**1**	**IV**	6	10
	Anisus vortex		**1**	**IV**		2
	Hippeutis complanatus		**3**	**V**	15	
Limpets and mussels						
Ancylidae grp.	*Acroloxus lacustris*	**6**	**2**		5	4
Sphaeriidae	*Sphaerium sp.*	**3**			5	30
	Pisidium sp.				32	1
Worms						
Oligochaeta		**1**			2	9
Leeches						
Glossiphoniidae	Glossiphoniidae (juvenile / damaged)	**3**		**IV**	1	1
Erpobdellidae	*Erpobdella sp.*	**3**				1
Piscicolidae	*Piscicola sp.*	**4**		**II**		1
Crustaceans						
Cladocera		**-**			40	
Crangonyctidae	*Crangonyx pseudogracilis*	**6**	**1**	**III**	150	60
Asellidae	*Asellus aquaticus*	**3**	**1**	**IV**	150	100
Mayflies						
Baetidae	Baetidae (juvenile / damaged)	**4**		**II**	35	1
Damselflies						
Coenagrionidae	*Coenagrion sp.*	**6**			5	15
Gerridae	*Gerris argentatus*	**5**	**5**			1
Nepidae	*Ranatra linearis*	**5**	**5**	**V**		2
Notonectidae	*Notonecta glauca*	**5**	**1**	**IV**	2	1
Beetles						
Haliplidae	Haliplidae (larvae / damaged)	**5**		**IV**		1
	Haliplus confinis		**2**	**IV**		1
Gyrinidae	*Gyrinus marinus*	**5**	**2**	**V**		2
Dytiscidae group	Dytiscidae (larvae / damaged)	**5**		**IV**	5	
	Hyphydrus ovatus		**2**	**IV**		1
	Anacaena lutescens		**3**	**IV**		5
Alderflies						
Sialidae	*Sialis lutaria*	**4**	**1**	**IV**		25
Caddisflies						
Polycentropodidae	*Holocentropus dubius*	**7**	**4**	**V**		3
Trueflies						
Chironomidae	Tanypodinae	**2**			1	
	Orthocladiinae				1	
	Chironomini				6	35
Tipulidae group	*Eleophila* sp.	**5**				1
	Tipulidae			**IV**	1	
Empididae		**-**				1
Stratiomyidae	*Oxycera* sp.				1	
Other Taxa						
Lepidoptera		**-**				50
Number of scoring families					**19**	**28**
Number of non-scoring families					**2**	**3**
Total number of families					**21**	**31**
BMWP score					**75**	**118**
ASPT					**3.9**	**4.2**

BMWP group	Species	BMWP score	CS	Flow group	Site 10 (184157)	
					May-16	Sep-16
LIFE Score					**6.0**	**6.0**
CCI Score					**5.0**	**10.9**

The results shown in Table 3.8, above, indicate that Kennington Pit is of good biological quality (BMWP scores 75 to 118, ASPT 3.9 to 4.2), with samples characterised by a relatively high diversity (21 to 31 families recorded present) and the presence of several taxa considered to be moderately sensitive to pollution, such as *Coenagrion* sp. (damselfly larvae), *Acroloxus lacustris* (limpet), *Holocentrropus dubius* (caddisfly larvae) and *Crangonyx pseudogracilis* (crustacean).

LIFE scores are generally used to assess the flow sensitivity of invertebrate communities and species in flowing watercourses rather than ponds, so are not particularly relevant for ponds. However, for comparison, most of the taxa recorded are typical of slow flowing / standing conditions (flow groups III, IV, V), with the exception of the leech *Piscicola* sp. and the mayfly Baetidae (flow group II). This is reflected by the low LIFE scores (6.0), thus confirming that the community is adapted to still water conditions that characterise this pond habitat.

In terms of conservation value, all of the species recorded are common, with the exception of the diving water strider *Gerris argentatus,* the water scorpion *Ranatra linearis* and the snail *Bythinia leachi* (Conservation Score 5, 'Local'), as demonstrated by the CCI scores, which are indicative of 'Low' to 'Moderate' conservation value.

PSYM analysis of pond survey data is being undertaken by the Freshwater Habitats Trust. The results of the analysis will be provided when this analysis has been completed.

3.2.8 Weirs Mill Stream (Site 11 - 184159)

Table 3.2 below presents the results of the macroinvertebrate analyses undertaken in May and September 2016 in Weirs Mill Stream.

Table 3.9: Macroinvertebrate taxa list for Weirs Mill Stream

BMWP group	Species	BMWP score	Conservation Score	Flow group	Site 11 (184159)	
					May-16	Sep-16
Snails						
Hydrobiidae	*Potamopyrgus antipodarum*	**3**	**1**	**III**		4
Limpets and mussels						
Ancylidae grp.	*Ancylius fluviatilis*	**6**	**1**	**II**		1
Sphaeriidae	*Sphaerium sp.*	**3**			2	1
	Sphaerium rivicola		**3**	**III**	1	
	Pisidium sp.				5	2
	Pisidium species to be confirmed					
Unionidae	*Unio pictorum*	**6**	**3**	**IV**		1
	Unio tumidus		**5**	**III**	9	
Cyrenidae	*Corbicula fluminea*				1	1
Worms						
Oligochaeta		**1**			11	
Crustaceans						
Cladocera		**-**			52	
Gammaridae grp.	*Dikerogammarus haemobaphes*	**6**			124	15
Crangonyctidae	*Crangonyx pseudogracilis*	**6**	**1**	**III**	7	
Corophidae	*Corophium curvispinum*	**6**	**3**	**III**	112	25
Astacidae	*Pacifastacus leniusculus*	**8**			1	1
Asellidae	*Asellus aquaticus*	**3**	**1**	**IV**	1	
Mayflies						

BMWP group	Species	BMWP score	Conservation Score	Flow group	Site 11 (184159)	
					May-16	Sep-16
Baetidae	*Baetis rhodani*	**4**	**1**	**II**	45	
	Centroptilum luteolum		**4**	**III**	2	
	Cloeon dipterum		**1**	**IV**	2	
Caenidae	*Caenis sp.*	**7**			2	8
	Caenis luctuosa		**1**	**IV**	9	
True bugs						
Notonectidae	*Notonecta glauca*	**5**	**1**	**IV**		1
Caddisflies						
Psychomyiidae	*Lype reducta*	**8**	**3**	**II**	3	
Leptoceridae	*Athripsodes cinereus*	**10**	**1**	**II**	1	
	Mystacides longicornis		**1**	**IV**		1
Trueflies						
Chironomidae	Chironomidae (damaged)	**2**			6	
	Orthocladiinae				96	12
	Chironomini				8	
Empididae		**-**			3	
Other Taxa						
Lepidoptera		**-**			1	
Number of scoring families					**11**	**10**
Number of non-scoring families					**3**	**0**
Total number of families					**14**	**10**
BMWP score					**64**	**62**
ASPT					**5.8**	**6.2**
LIFE Score					**7.1**	**6.7**
CCI Score					**10.5**	**5.0**

The data suggest that Weirs Mill Stream is of moderate biological quality (BMWP scores 62 to 64, ASPT 5.8 to 6.2), with samples characterised by a relatively low diversity of invertebrates (10 to 14 families recorded) and the presence of several taxa considered to be moderately sensitive to pollution, such as crustaceans (Corpohidae, Gammaridae), limpets (Ancylidae) and mayfly larvae (Caenidae).

In terms of flow sensitivity, the samples comprise taxa typical of rapid to fast flowing conditions (flow groups I and II), such as *Ancylus fluvialtilis* and *Lype reducta* and species adapted to slower flows (flow groups III and IV), such as true bugs (*Notonecta glauca*), as shown by the moderate LIFE score (6.7 to 7.1).

All of the species that were recorded are common, with the exception of the mussel *Unio tumidus* (Conservation Score 5, 'Local'). This is shown in the CCI scores indicative of 'Low' to 'Moderate' conservation value (5.0 to 10.5).

3.2.9 River Thames (Site 12 - 184146 and Site 13 - 184145)

The Table 3.10 below presents the results of the macroinvertebrate analyses undertaken in May and September 2016 in the River Thames.

Table 3.10: Macroinvertebrate taxa list for the River Thames

BMWP group	Species	BMWP score	Conservation Score	Flow group	Site 12 (184146)		Site 13 (184145)	
					May-16	Sep-16	May-16	Sep-16
Snails								
Viviparidae	*Viviparus sp.*	**6**					1	
Hydrobiidae	*Potamopyrgus antipodarum*	**3**	**1**	**III**			36	27

BMWP group	Species	BMWP score	Conservation Score	Flow group	Site 12 (184146)		Site 13 (184145)	
					May-16	Sep-16	May-16	Sep-16
Succinea	*Succinea* sp.	-				1		
Planorbidae	*Planorbarius corneus*	3	4	IV			1	
Limpets and mussels								
Ancylidae grp.	*Ancylius fluviatilis*	6	1	II		2	3	1
	Acroloxus lacustris		2		1			
Sphaeriidae	Sphaeriidae (juvenile / damaged)	3		IV				
	Sphaerium sp.						46	10
	Sphaerium rivicola		3	III			6	
	Pisidium sp.				2	3	18	16
Unionidae	*Unio pictorum*	6	3	IV			2	
	Unio tumidus		5	III			9	
	Anodonta anatina		3	III			24	7
Cyrenidae	*Corbicula fluminea*						4	17
Worms								
Oligochaeta		1			19		32	4
Leeches								
Erpobdellidae	*Erbodella octoculata*	3	1	IV			1	
Crustaceans								
Cladocera		-					1	
Gammaridae grp	*Gammarus* sp.	6			10			
	Gammarus pulex		1	II		5		
	Dikerogammarus haemobaphes				48	5	102	6
Crangonyctidae	*Crangonyx pseudogracilis*		1	III		4		
Corophidae	*Corophium curvispinum*	6	3	III	96	165	9	8
Astacidae	*Pacifastacus leniusculus*	8			1	3	1	
Asellidae	*Asellus aquaticus*	3	1	IV			2	
Mayflies								
Baetidae	Baetidae (juvenile / damaged)	4		II	14		3	
Ephemeridae	*Ephemera sp.*	10				1		
	Ephemera danica		1	II			1	
Caenidae	*Caenis luctuosa*	7	1	IV		1	1	17
	Caenis robusta		5	IV	2			
Caddisflies								
Psychomyiidae	*Lype reducta*	8	3	II	1			
Limnephilidae	*Limnephilus lunatus*	7	1	IV	5			
Leptoceridae	*Athripsodes sp.*	10						1
	Athripsodes cinereus		1	II			5	
Ecnomidae	*Ecnomus tenellus*		5	III	1			
Trueflies								
Chironomidae	Chironomidae (damaged)	2					1	1
	Tanypodinae						9	
	Orthocladiinae				30		5	
	Chironomini				11	20	113	30
	Tanytarsini				22			
	Prodiamesinae							5
Tipulidae group	Limoniidae	5			1	2		
Simuliidae	Simuliidae (damaged / juvenile)	5		II			3	
	Simulium ornatum group		1				2	
Other Taxa								

BMWP group	Species	BMWP score	Conservation Score	Flow group	Site 12 (184146)		Site 13 (184145)	
					May-16	Sep-16	May-16	Sep-16
Lepidoptera		-				1		
Number of scoring families					**11**	**8**	**17**	**11**
Number of non-scoring families					**0**	**2**	**1**	**2**
Total number of families					**11**	**10**	**18**	**13**
BMWP score					**63**	**53**	**92**	**55**
ASPT					**5.7**	**6.6**	**5.4**	**5.0**
LIFE Score					**7.2**	**7.2**	**7.0**	**6.9**
CCI Score					**15.8**	**4.2**	**10.0**	**5.4**

The results above indicate that the River Thames is of good biological quality (BMWP scores 53 to 92, ASPT 5.0 to 6.6), with samples characterised by a moderate diversity of invertebrates (10 to 18 families recorded) and the presence of several taxa considered to be sensitive to pollution, including the highly sensitive *Athripsodes* spp. (caddisfly larvae) at Site 13, and *Ephemera* spp. (mayfly larvae) at both sites. Both sites were generally similar in terms of invertebrate sample composition, although more mollusc species were recorded at Site 13 than at Site 12.

The samples are largely dominated by taxa typical slow flowing or standing conditions (flow groups III, IV and V), such as snails and mussels (Unionidae) (Velidae, Notonectidae) and snails (*Potamopyrgus antipodarum, Bithynia tentaculata, Physa fontinalis, Gyraulus albus and Hippeutis complanatus*), as reflected in the moderate LIFE scores (6.9 to 7.2).

In terms of conservation value, all species recorded are common, with the exception of the caddisfly larvae *Ecnomus tenellus*, the mayfly larvae *Caenis robusta* (Site 12, May 2016) and the mussel *Unio tumidus* (Conservation Score 5, 'Local') at Site 13 in May 2016 in May 2016, as shown by the CCI score indicative of a 'High' conservation value for Site 12 in May 2016, Moderate for Site 13 in May 2016 and 'Low' for both sites in September 2016.

3.3 Mussel Sampling Results

Table 3.11 below presents the results of the mussel sampling undertaken. Additional data (i.e. length of the specimens collected, description of the survey conditions) are presented in Appendix C.

Table 3.11: Abundances of Unionidae species recorded

	Seacourt Stream		Bulstake Stream	Hinksey Stream			Eastwyke Ditch	Weirs Mill Stream	River Thames	
	Site 1	Site 2	Site 3	Site 4	Site 6	Site 9	Site 7	Site 11	Site 12	Site 13
Number of net transects / dredges	4	5	5	5	6	5	5	6	5	5
Anodonta anatina	1	0	3	0	0	3	0	1	0	6
Pseudano-donta complanata	1	0	2	0	0	0	0	0	0	1
Unio pictorum	2	0	4	1	0	2	0	0	0	2
Unio tumidus	10	0	16	7	0	0	0	0	0	2

As shown on the

Table 3.11 above, a total of 64 specimens and 4 species were recorded across the 10 sampling sites. The most abundant species recorded was the painter's mussel *Unio pictorum* (34 specimens), which was recorded in most of the watercourses surveyed, with the exception of Eastwyke Ditch and Weirs Mill Stream. A total of 14 specimens of the duck mussel *Anodonta anatina* and 11 specimens of the painter's mussel *Unio pictorum*, which were recorded across most watercourses sampled.

The highest diversity and abundances of mussels were recorded at Site 1 on the Seacourt Stream (although Site 2 on the same watercourse recorded no unionids), Site 3 on Bulsake Stream, Site 9 on Hinksey Stream (although upstream on the same watercourse, lower numbers were recorded at Site 4 and no unionids at all were recorded at Site 6) and the River Thames (Site 13, samples collected at Site 12 on the same watercourse recorded no unionids).

The depressed river mussel *Pseudanodonta complanata* (**Error! Reference source not found.**) was only recorded in low abundances (4 specimens in total), on Seacourt Stream (Site 1), Bulstake Stream (Site 3) and the River Thames (Site 13).

4. Discussion

4.1.1 General

A total of 141 taxa were recorded throughout the 13 sites surveyed, of which 84 were identified to a species level, 24 to genus and another 33 to higher taxonomic levels.

The most diverse group were snails, caddisfly larvae, beetles, truefly larvae and mayfly larvae. Other groups included flatworms, limpets and mussels, leeches, crustaceans, damselfly larvae, true bugs, alderflies, Oligochaeta worms and Lepidoptera.

While most of the species recorded were very common, some more notable species were recorded and are presented in the Table 4.1 below. For the purpose of this discussion, only species with Conservation Scores of 6 or higher are described.

Table 4.1: Nature conservation notable species records

Species	Conservatio Score	Designation	Site	Number / Date
(*Gyraulus laevis* (smooth ramshorn)	**6**	No statutory or non-statutory designation	Hinksey Stream (Site 9)	2 specimens, in May-16
Brachycentrus subnubilus (caddis)	**6**	No statutory or non-statutory designation	Seacourt Stream (Site 1)	1 specimen, in Sep-16
Pseudanodonta complanata (depressed river mussel)	**7**	Species “of principal importance for the purpose of conserving biodiversity” Section 41 (England) of the NERC Act (2006), UK BAP priority species, Nationally Scarce, IUCN vulnerable	Seacourt Stream (Site 1)	1 specimen in Sep-16
			River Thames (Site 13)	1 specimen in Sep-16
			Bulstake Stream (Site 3)	2 specimens and 5 empty shells in Sep-16

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In addition, the non-native invasive demon shrimp (*Dikerogammarus haemobaphes)*, signal crayfish (*Pacifastacus leniusculus*) and Asian clam (*Corbicula fluminea)* were recorded at many sites, with only Hogacre Ditch (Site 5), Chiswell Stream (Site 8) and Kennington Pit (Site 10) appearing to be free of non-native invasive macroinvertebrate species, based on the data available.

4.1.2 Mussel Diversity

In terms of mussels, four species of Unionidae (*Pseudanodonta complanata, Anodonta anatina, Unio pictorum and Unio tumidus)* were recorded across the nine sites surveyed for mussels. Therefore, all four native lowland unionids were recorded during these surveys.

Seacourt Stream (Site 1 only), Bulsake Stream (Site 3), Hinksey Stream (Site 9 only) and the River Thames (Site 13 only) recorded the highest diversity and abundances of unionids, however, there was considerable differences between different sites on the same watercourse recorded (for example at Site 12 on the Thames no unionids were recorded).The differences in distributions of these species between the sites may reflect habitat and water quality differences. All four species require permanent (generally slow flowing) waters, fine sediment substrate and relatively good water quality. There is not sufficient data or sample sites to be able to determine which of the factors is the most important in explaining the distributions, and some unionids are considered as having a ‘patchy distribution’ (Aldridge, 2002) meaning density distribution is inherently variable and therefore diversity and abundance data are difficult to interpret. However, both habitat and water quality are likely to be important factors.

The depressed river mussel *Pseudanodonta complanata* was recorded in low abundances from three waterbodies, the River Thames, Seacourt Stream and Bulstake Stream. The depressed river mussel

is of particular concern, as it is reported to be rare or threatened across most of its European range and it is listed by the International Union for Conservation of Nature (IUCN) as globally Vulnerable. In the UK, estimates indicate that the species distribution has declined by approximately 30% in the last 100 years (Aldridge, 2004) but despite this the UK is still thought to support one of the healthiest populations in Europe and therefore UK populations are of high nature conservation value. This is reflected in the listing of the depressed river mussel as a species "of principal importance for the purpose of conserving biodiversity" under Section 41 (England) of the Natural Environment and Rural Communities (NERC) Act (2006).

Depressed river mussel is not a Red Data Book (RDB) species (Bratton, 1991), but is considered as being as notable under the Community Conservation Index (CCI) for freshwater invertebrates (Chadd & Extence, 2004). It has a Conservation Score of 7, the highest CS within this system not to be awarded RDB status.

While depressed river mussel and other unionids are not generally considered to be sensitive to changes in flow velocity, reduced flow as a result of the FAS may alter the type and availably of suitable submerged habitats (of key importance to depressed river mussel, according to Aldrige, 2002), modify sediment dynamics (e.g. reduce remobilisation of sediments, change areas of deposition) and affect fish populations, which play a key role in unionid reproduction and population dynamics.

4.1.3 Appraisal of Relative Conservation Value and Waterbody Sensitivity

Table 4.2, below, provides a summary of the different sites, based on the results of the macroinvertebrate analyses and mussel surveys undertaken.

An appraisal of the conservation value and sensitivity of sample sites has been completed and is provided in Table 4.2, below. This appraisal is based on our professional judgement of the relative diversity, pollution sensitivity and rarity of macroinvertebrate species and communities recorded at each of the sites. It only considers macroinvertebrate communities at sites surveyed as part of this study, relative to each other, and does not attempt to describe the absolute value or sensitivity of any of the sites or communities. While this appraisal is not the same as the CCI scoring system (discussed elsewhere in this document) it uses the Conservation Scores from the CCI, as well as other designations, as a means of identifying less common species present within the samples..

The appraisal has defined three different 'classes' of relative sensitivity and importance for the purpose of this investigation, as follows;

- High – invertebrate community of high diversity, usually including one or several notable species (Conservation Score > 5)
- Medium - invertebrate community of moderate relative diversity, with few or no notable species recorded (Conservation Score >5)
- Low - invertebrate community of low relative diversity, without notable species (Conservation Score >5)

As shown in Table 4.2, the sites which are considered to be of the highest conservation value and sensitivity are those on Seacourt Stream (Sites 1 and 2), Bulstake Stream (Site 3) and Site 13 on the River Thames. However, Sites 4 and 9 (on Hinksey Stream) also appeared to be of relatively high value.

The flow sensitivity of the communities is considered as being particularly important part of this investigation, as FAS may modify flows in several of the waterbodies surveyed. The invertebrate data indicate that the invertebrate communities present at most of the sites are largely dominated by species tolerant to slow flowing and / or standing conditions, and therefore unlikely to be highly sensitive to flow reductions. However, as summarised in Table 4,2, below, several sites also support species typical of faster flows, which are therefore more likely to be sensitive to flow reductions. These include Bulstake Stream (Site 3), Seacourt Stream (Site 1 especially but also Site 2), Weirs Mill Stream (Site 11) Hinksey Stream (Site 4 and Site 9), Chiswell Stream (Site 8).

Given that Sites 1 and 2 on Seacourt Stream and Site 3 on Bulstake Stream are considered as being of relatively high conservation value and sensitivity, and that these sites are also deemed as having

invertebrate communities that are most sensitive to flow reductions, there is greater potential for impacts on these communities from any flow reductions associated with the FAS. On the other hand, the River Thames is characterised by taxa that are associated with low flow conditions and are not likely to be affected by changes in flow. Furthermore, given the size and morphology of the Thames sites surveyed (steep sides), it is less likely that modifications to flow would affect the invertebrate communities that are present.

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Table 4.2: Sensitivity of the different sample sites in terms of mussels and other macroinvertebrate groups

Watercourse	Site	Flow sensitivity	Macroinvertebrates – Appraisal of Conservation Value	Notable species	Mussel Diversity	Non-native invasive species
Seacourt Stream	Site 1	Relatively high – samples include several flow sensitive taxa.	High – relatively high diversity of macroinvertebrate taxa, including several pollution sensitive families and two notable species.	*P. complanata. B. subnubilus*	High diversity and abundances of unionids, with four species recorded (*Anodonta anatina, Pseudanodonta complanata, Unio pictorum, Unio tumidus*)	*D. haemobaphes*
	Site 2	Relatively high - samples include several flow sensitive taxa.	High / Medium - relatively high diversity of macroinvertebrate taxa, including several pollution sensitive families). No notable species recorded.		No unionids recorded	*D. haemobaphes*
Bulstake Stream	Site 3	Relatively high - samples include several flow sensitive taxa.	High – high diversity of macroinvertebrate taxa recorded. The sample includes several pollution sensitive families. While most the taxa were common, *P. complanata* was recorded at this site.	*P. complanata*	High diversity and abundances of unionids, with four species recorded (*Anodonta anatina, Pseudanodonta complanata, Unio pictorum, Unio tumidus*)	*D. haemobaphes, P. leniusculus*
Hinksey Stream	Site 4	Moderate	Medium / High – high diversity of macroinvertebrate taxa recorded. The sample includes several pollution sensitive families. All of the species recorded were common		Medium – only *Unio pictorum* and *Unio tumidus* recorded	*D. haemobaphes, P. leniusculus*
	Site 6	Relatively low	Medium – relatively high diversity of macroinvertebrate taxa recorded. However, while the samples include some pollution sensitive families, they are generally dominated by pollution tolerant group. All of the species recorded were common		No unionids recorded	*D. haemobaphes, P. leniusculus*
	Site 9	Moderate	Medium / High – high diversity of macroinvertebrate taxa recorded. However, while the samples include some pollution sensitive families, they are generally dominated by pollution tolerant groups. While most the taxa were common *G. laevis* (CS 6) was recorded at this site.	*G. laevis*	Poor – only *Unio pictorum* recorded (two individuals)	*D. haemobaphes*
Hogacre Ditch	Site 5	Low – communities dominated by species adapted to slow flowing conditions	Low – samples characterised by a low taxa diversity, with pollution tolerant groups dominant and lacking in pollution tolerant families, All species common.		No mussel survey completed.	

Watercourse	Site	Flow sensitivity	Macroinvertebrates – Appraisal of Conservation Value	Notable species	Mussel Diversity	Non-native invasive species
Eastwyke Ditch	Site 7	Relatively low – most taxa recorded are typical of slow flowing / standing conditions	Medium - samples characterised by moderate taxa diversity, pollution tolerant groups dominant but several pollution sensitive groups also present. All species common, except the soldierfly *Oxycera pygmaea*	*Oxycera pygmaea*	No unionids recorded.	*D. haemobaphes, P. leniusculus*
Chiswell Stream	Site 8	Low - most taxa recorded are typical of slow flowing / standing conditions	Medium/Low – low/moderate diversity of invertebrates recorded, with sample dominated by pollution tolerant groups, although low numbers of pollution sensitive taxa were recorded. Most species present were common, and no notable species were recorded.	‘	No mussel survey completed.	
Kennington Pit	Site 10	Low (only pond species recorded).	Medium - relatively high diversity of invertebrates recorded, including some pollution sensitive taxa. While no notable species were recorded, several ‘Local’ species were present.		No mussel survey completed.	
Weirs Mill Stream	Site 11	Relatively high - taxa typical of rapid to fast flowing conditions	Medium – low/moderate diversity of invertebrates recorded, including several pollution sensitive taxa. While no notable species were recorded, several ‘Local’ species were present.		Poor – only *Anodonta anatina* recorded (one individual)	*D. haemobaphes, P. leniusculus, C. fluminea*
River Thames	Site 12	Relatively low - dominated by taxa typical slow flowing or standing conditions	Medium - moderate diversity of invertebrates recorded, including some pollution sensitive taxa. While no notable species were recorded, several ‘Local’ species were present.		Poor - no unionids recorded.	*D. haemobaphes, P. leniusculus, C. fluminea*
	Site 13	Relatively low	High – high diversity of macroinvertebrate taxa recorded. The sample includes several pollution sensitive families. While most the taxa were common, *P. complanata* was recorded at this site.	*P. complanata*	High diversity unionids, with four species recorded (*Anodonta anatina, Pseudanodonta complanata, Unio pictorum, Unio tumidus*)	*D. haemobaphes, P. leniusculus, C. fluminea*

5. Conclusion

The objectives of the macroinvertebrate and freshwater mussel (Unionidae) surveys and analyses undertaken by AECOM were to assess the ecological value and sensitivity of nine watercourses (across 13 sites) in terms of macroinvertebrate communities, in order to inform an assessment of the Oxford Flood Alleviation Scheme.

The assessment was made based upon macroinvertebrate data from two sampling sessions, undertaken in spring 2016 by the Environment Agency and in autumn 2016 by AECOM. In addition, AECOM undertook specific mussel surveys on six watercourses (9 sites) in autumn (September) 2016.

The surveys identified a range of macroinvertebrate species and communities across the 13 sample sites. The presence of several notable species of conservation was identified:

- the depressed river mussel *Pseudanodonata complanata* in the River Thames, Seacourt Stream, Bulstake Stream;
- the smooth Ramshorn *Gyraulus laevis* in Hinksey Stream; and
- the caddisfly *Brachycentrus subnubilus* in Seacourt Stream

The mussel survey found that Seacourt Stream (Site 1 only), Bulstake Stream (Site 3), Hinksey Stream (Site 9 only) and the River Thames (Site 13 only) recorded the highest diversity and abundances of unionids, However, there was significant variability between sites on the same watercourse. The depressed river mussel *Pseudanodonta complanata* was recorded in low abundances from three waterbodies, the River Thames, Seacourt Stream and Bulstake Stream. The depressed river mussel is of particular concern, as it is reported to be rare or threatened across most of its European range and it is listed by the International Union for Conservation of Nature (IUCN) as globally Vulnerable.

The analysis and appraisal of the different species and communities recorded (in terms of diversity, presence of notable species and pollution sensitivity) found that the sites which are considered to be of the highest conservation value and sensitivity are those on Seacourt Stream (Sites 1 and 2), Bulstake Stream (Site 3) and Site 13 on the River Thames. However, Sites 4 and 9 (on Hinksey Stream) also appeared to be of relatively high value and sensitivity. In addition, Sites 1 and 2 on Seacourt Stream and Site 3 on Bulstake Stream are also considered as having invertebrate communities that are most sensitive to flow reductions. Therefore, these sites are particularly sensitive to changes in flow reductions associated with the FAS.

Other waterbodies (Hogacre Ditch, Kennington Pit and Chiswell Stream) appeared to be of less conservation value and lower sensitivity.

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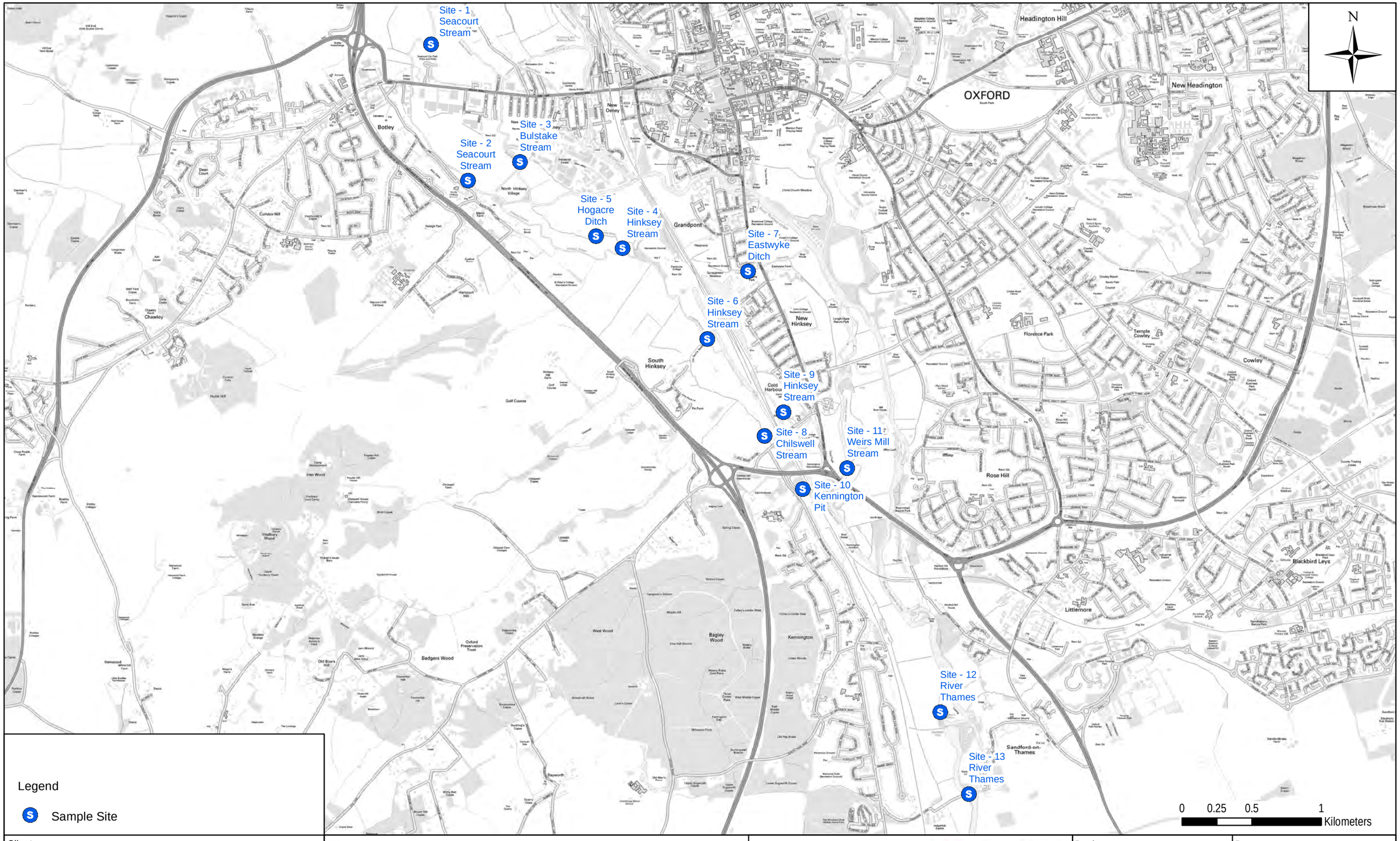
Willing, M.J. 2006. River Arun Scoping Study: Further surveys for the (1) Swollen Spire Snail (Mercuria confusa) and (2) Compressed River Mussel (Pseudanodonta complanata) July – October 2006 (provided by Atkins)

Appendix A Site Location Map



Legend

S Sample Site

Client:	Title: MACROINVERTEBRATE SAMPLING SITES		Design: NG / Drawn: GB
Project: OXFORD FAS			Chk'd: NG / App'd: NG
			Date: 02/12/2016 / Scale at A3: 1:25,000
			Drawing Number: FIGURE 1 / A3

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Appendix B Site Photographs

Plate B1: Site 1 (Seacourt Stream)

Plate B2: Site 2 (Seacourt Stream)

Plate B3: Site 3 (Bulstake Stream)

Plate B4: Site 4 (Hinksey Stream)

Plate B5: Site 5 (Hogacre Stream)

Plate B6: Site 6 (Hinksey Stream)

Plate B7: Site 7 (Eastwyke Ditch)

Plate B8: Site 8 (Chiswell Stream)

Plate B9: Site 9 (Hinksey Stream)

Plate B10: Site 10 (Kennington Pit)

Plate B11: Site 11 (Weirs Mill Stream)

Plate B12: Site 12 (River Thames)

Plate B13: Site 13 (River Thames)

Plate B14: Signal crayfish (*Pacifastacus leniusculus*) collected in Hinksey Stream

Plate B15: Asian clam (*Corbicula fluminea*) collected in the River Thames

Plate B16: Modified pond net used for Unionidae surveys

Appendix C Mussel Survey Results

Table C1: Unionidae abundances / length data for Seacourt Stream

	Site 1				Site 2				
Transect	**T1**	**T2**	**T3**	**T4**	**T1**	**T2**	**T3**	**T4**	**T5**
Description	Silt substrate	Silt substrate	Silt substrate	Silt substrate	Silt substrate	Silt substrate	Silt and sand substrate	Silt and sand substrate	Sand, gravel and silt substrate
Number of nets	8	10	10	10	10	10	10	10	10
Net type (M=modified, S=standard)	S	S	S	S	S	S	S	S	S
Anodonta anatina (N individuals (length))	0	0	1 (5.6 cm)	0	0	0	0	0	0
Pseudanodonta complanata ((N individuals (length))	0	0	0	1 (5.4 cm)	0	0	0	0	0
Unio pictorum (N individuals (length))	0	1 (4.5 cm)	1 (5 cm)	0	0	0	0	0	0
Unio tumidus (N individuals (length))	1 (5.4 cm)	1 (5.6 cm)	1 (5.4 cm)	7 (5.3 cm, 4.8 cm, 4.6 cm, 4.4 cm, 4.9 cm, 5.5 cm, 4.3 cm)	0	0	0	0	0

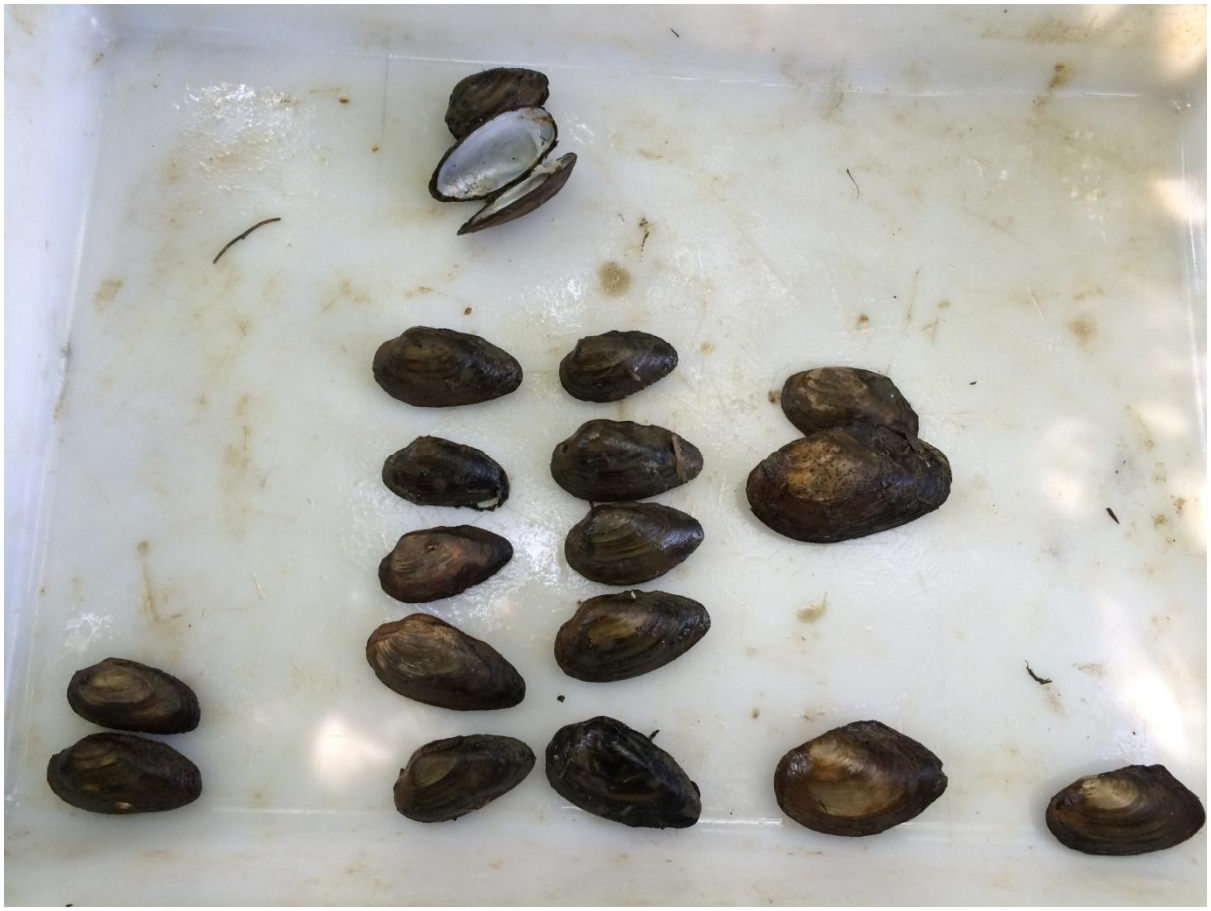

Plate C1: Unionidae specimen collected in Seacourt Stream (Site 1)

Plate C2: Depressed river mussel (*Pseudanodonta complanata*) sampled at Site 1

Table C2: Unionidae abundances / length data for Bulstake Stream (Site 3)

	Site 3				
Transect	**T1**	**T2**	**T3**	**T4**	**T5**
Description	Central channel, stony substrate	Marginal, silt substrate	Marginal, silt substrate	Marginal, silt substrate	Central channel, stony substrate
Number of nets	10	10	10	10	10
Net type (M=modified, S=standard)	M	M	M	M	M
Anodonta anatina (N individuals (length))	0	1 (5.9 cm)	0	1 (7 cm)	1 (6.1 cm)
Pseudanodonta complanata ((N individuals (length))		2 (6.2 cm, 5.9 cm)	0	0	0
Unio pictorum (N individuals (length))	1 (4.4 cm)	0	1 (6.1 cm)	0	2 (4.5 cm, 5.3 cm)
Unio tumidus (N individuals (length))	5 (4.2 cm, 4.5 cm, 4.0 cm, 3.1 cm, 4.1 cm)	4 (2.8 cm, 2.1 cm, 2.8 cm, 1.7 cm)	5 (4.5 cm, 4.1 cm, 3.6 cm, 5.7 cm, 4.7 cm)	0	2 (5.1 cm, 4.6 cm)

Plate C3: Unionidae specimen collected in Bulstake Stream (Site 3)

Table C3: Unionidae abundances / length data for Hinksey Stream (Site 4)

	Site 4				
Transect	**T1**	**T2**	**T3**	**T4**	**T5**
Description	Marginal area, clay, silt, gravel and sand substrate	Marginal area, sand and silt substrate	Marginal area, silty substrate	Central channel, loose gravel substrate	Marginal area, loose gravel, pebble and silt substrate
Number of nets	10	10	10	10	10
Net type (M=modified, S=standard)	M	M	M	M	M
Anodonta anatina (N individuals (length))	0	0	0	0	0
Pseudanodonta complanata ((N individuals (length))	0	0	0	0	0
Unio pictorum (N individuals (length))	0	0	1 (3.7 cm)	0	0
Unio tumidus (N individuals (length))	1 (2.3 cm)	5 (1.1 cm, 1.2 cm, 1.3 cm, 4.5 cm, 5 cm)	0	0	1 (2.3 cm)

Plate C4: Unionidae specimen collected in Hinksey Stream Stream (Site 4)

Table C4: Unionidae abundances / length data for Hinksey Stream (Site 6)

	Site 6					
Transect	**T1**	**T2**	**T3**	**T4**	**T5**	**T6**
Description	Central channel, gravel and pebbles substrate	Marginal area, gravel substrate	Marginal area, gravel and silt substrate	Marginal area, loose gravel substrate	Central channel, stony substrate	Marginal area, silty substrate
Number of nets	8	10	10	10	3	10
Net type (M=modified, S=standard)	M	M	M	M	M	S
Anodonta anatina (N individuals (length))	0	0	0	0	0	0
Pseudanodonta complanata ((N individuals (length))	0	0	0	0	0	0
Unio pictorum (N individuals (length))	0	0	0	0	0	0
Unio tumidus (N individuals (length))	0	0	0	0	0	0

Table C5: Unionidae abundances / length data for Hinksey Stream (Site 9)

	Site 9				
Transect	**T1**	**T2**	**T3**	**T4**	**T5**
Description	Central channel, gravel, sand, pebbles and silt	Marginal, silt with sand and gravel	Marginal, silt with sand and gravel, shallow area	Central channel, sand and gravel substrate	Marginal, sand and gravel substrate
Number of nets	10	10	10	10	10
Net type (M=modified, S=standard)	M	M	M	M	M
Anodonta anatina (N individuals (length))	0	0	1 (5.6 cm)	0	2 (5.7 cm and 6.1 cm)
Pseudanodonta complanata ((N individuals (length))	0	0	0	0	0
Unio pictorum (N individuals (length))	0	0	0	2 (4.3 cm and 4.4 cm)	0
Unio tumidus (N individuals (length))	0	0	0	0	0

Plate C5: Unionidae specimen collected in Hinksey Stream Stream (Site 9)

Table C6: Unionidae abundances / length data for Eastwyke Ditch (Site 7)

	Site 7				
Transect	**T1**	**T2**	**T3**	**T4**	**T5**
Description	Central channel, gravel, pebbles and silt substrate	Marginal area, gravel, pebbles and silt substrate	Marginal area, gravel, pebbles and silt substrate	Marginal area, gravel, pebbles and silt substrate	Marginal area, gravel, pebbles and silt substrate
Number of nets	**10**	**10**	**10**	**10**	**10**
Net type (M=modified, S=standard)	M	M	M	M	M
Anodonta anatina (N individuals (length))	0	0	0	0	0
Pseudanodonta complanata ((N individuals (length))	0	0	0	0	0
Unio pictorum (N individuals (length))	0	0	0	0	0
Unio tumidus (N individuals (length))	0	0	0	0	0

Table C7: Unionidae abundances / length data for Weirs Mill Stream (Site 11)

	Site 11					
Dredge	**D1**	**D2**	**D3**	**D4**	**D5**	**D6**
Description	Gravel and sand substrate	Gravel and sand substrate	Gravel and sand substrate	Gravel and sand substrate	Gravel and sand substrate	Clay and sand substrate
Anodonta anatina (N individuals (length))	0	0	1 (2.4 cm)	0	0	0
Pseudanodonta complanata ((N individuals (length))	0	0	0	0	0	0
Unio pictorum (N individuals (length))	0	0	0	0	0	0
Unio tumidus (N individuals (length))	0	0	0	0	0	0

Plate C6: Unionidae specimen collected in Weirs Mill Stream (Site 11)

Table C8: Unionidae abundances / length data for the River Thames

	Site 12				Site 13				
Dredge	**D1**	**D2**	**D3**	**D4**	**D1**	**D2**	**D3**	**D4**	**D5**
Description	Clay and gravel substrate	Clay and gravel substrate	Clay and gravel substrate	Clay and gravel substrate	Silt, gravel and sand substrate	Silt, gravel and sand substrate	Silt, gravel and sand substrate	Silt, gravel and sand substrate	Silt, gravel and sand substrate
Anodonta anatina (N individuals (length))	0	0	0	0	0	0	1 (6.7 cm)	5 (2.6 cm, 4.4. cm, 7.5 cm, 7.7 cm)	0
Pseudanodonta complanata ((N individuals (length))	0	0	0	0	0	0	0	1 (4.9 cm)	0
Unio pictorum (N individuals (length))	0	0	0	0	1 (6 cm)	0	1 (6 cm)	0	0
Unio tumidus (N individuals (length))	0	0	0	0	1 (3.5 cm)	0	1	1 (5.2 cm)	0

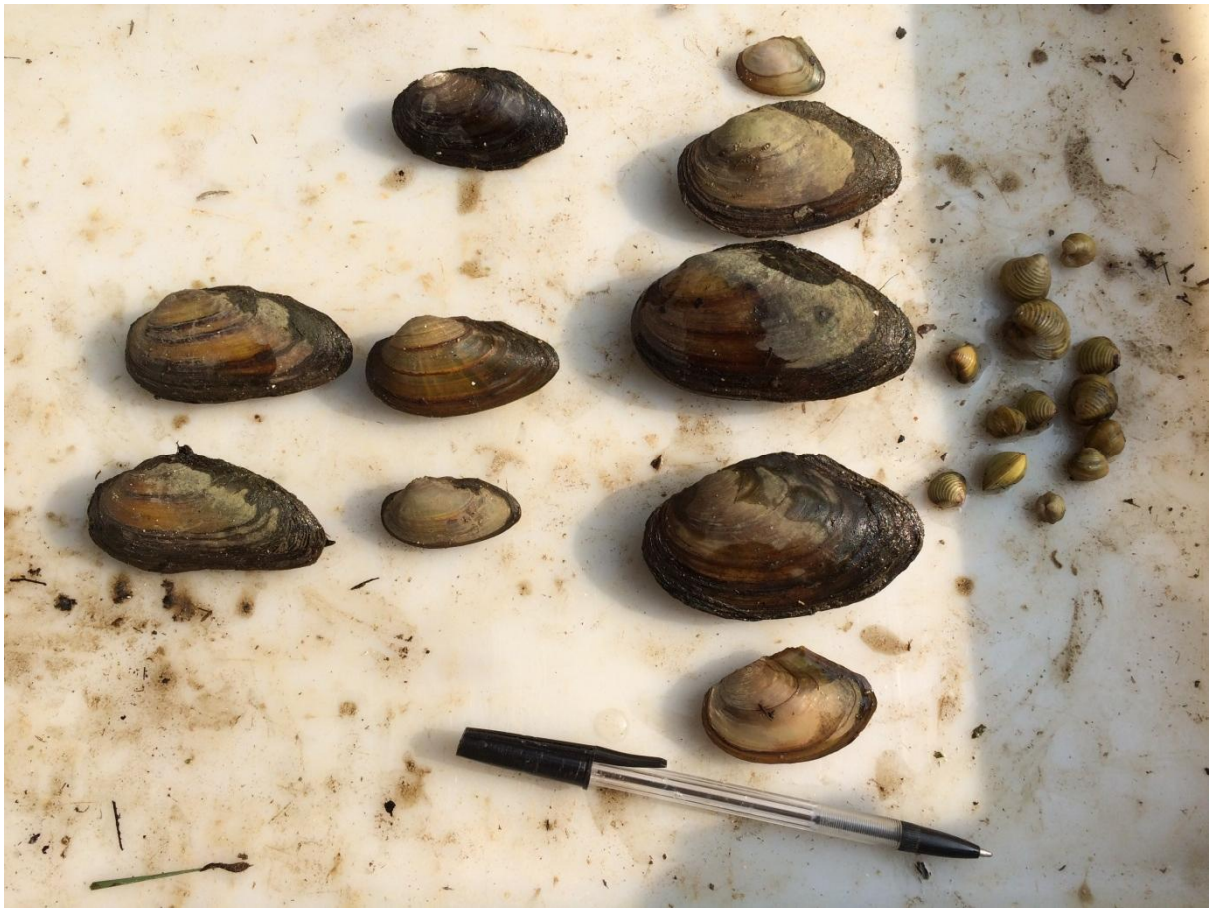

Plate C7: Unionidae specimen collected in Weirs Mill Stream (Site 11)

Plate C8: Depressed river mussel (*Pseudanodonta complanata*) sampled at Site 13

Appendix D Biological Monitoring Waterbody BMWP) System

There are about 4,000 species of aquatic macro-invertebrates in the British Isles. To simplify the analysis of the samples and the data we do not identify individual species but only the major types (taxa), mostly at the family taxonomic level. A key piece of information is the number of different taxa at a site. A fall in the number of taxa indicates ecological damage, including pollution (organic, toxic and physical pollution such as siltation, and damage to habitats or the river channel).

For consistency, we only report taxa used in the BMWP (Biological Monitoring Working Party) system (see below). Some animals are more susceptible to organic pollution than others and the presence of sensitive species indicates good water quality. This fact is taken into account by the BMWP System.

The BMWP system assigns a numerical value to about 80 different taxa (known as the BMWP-scoring families) according to their sensitivity to organic pollution. The average of the values for each taxon in a sample, known as ASPT (average score per taxon) is a stable and reliable index of organic pollution. Values lower than expected indicate organic pollution.

The most useful way of summarising the biological data was found to be one that combined the number of taxa and the ASPT. The best quality is indicated by a diverse variety of taxa, especially those that are sensitive to pollution. Poorer quality is indicated by a smaller than expected number of taxa, particularly those that are sensitive to pollution. Organic pollution sometimes encourages an increased abundance of the few taxa that can tolerate it.

The biotic scores can be interpreted by following the guidelines in the table below (taken from Armitage et al., 1983; Chapman, 1996; Mason, 2002). However, these categories are for guidance only and it should be remembered that maximum achievable values will vary between geological regions.

For example, pristine lowland streams in East Anglia will always score lower than pristine Welsh mountain streams as they are unable to support many of the high-scoring taxa associated with fast flowing habitat. BMWP scores and ASPT for different types watercourse are dependent on the quality and diversity of habitat, natural water chemistry (associated with geology, distance from source etc.), altitude, gradient, time of year the sample was taken and other factors.

Table D1: A guide to interpreting BMWP Score and ASPT

BMWP score	ASPT	Interpretation
0-10	<3.0	Very poor, heavily polluted
11-40	3.0-4.3	Poor, polluted or impacted
41-70	4.3-4.8	Moderate, moderately impacted
71-100	4.8-5.4	Good, clean but slightly impacted
>100	>5.4	Very good, unpolluted, unimpacted

Appendix E Community Conservation Index (CCI)

The Community Conservation Index (Chadd & Extence, 2004) allows a classification of the nature conservation value associated with a macroinvertebrate community. The CCI score for one sample is derived from individual Conservation Scores (CS), assigned to some species of aquatic macroinvertebrates and relating closely to the available published Red Data Books (Bratton, 1991a, b; Shirt, 1987). Conservation Scores assigned to individual species vary from 1 to 10, as detailed on the Table B1 below. The derived CCI scores generally vary from 0 to > 20, as detailed in the Table B2 below. The Table B3 below provides a guide to interpreting CCI scores.

Table E1: Conservation Scores from the Community Conservation Index (from Chadd & Extence, 2004)

Conservation Score	Relation to Red Data Books
10	RDB1 (Endangered)
9	RDB2 (Vulnerable)
8	RDB3 (Rare)
7	Notable (but not RDB status)
6	Regionally notable
5	Local
4	Occasional (species not in categories 10-5, which occur in up to 10% of all samples from similar habitats)
3	Frequent (species not in categories 10-5, which occur in up to >10-25% of all samples from similar habitats)
2	Common (species not in categories 10-5, which occur in up to >25-50% of all samples from similar habitats)
1	Very common (species not in categories 10-5, which occur in up to >50-100 % of all samples from similar habitats)

Table E2: General guide to CCI scores (from Chadd & Extence, 2004)

CCI Score	Description	Interpretation
0 to 5.0	Sites supporting only common species and/or community of low taxon richness	Low conservation value
> 5.0 to 10.0	Sites supporting at least one species of restricted distribution and/or a community of moderate taxon richness	Moderate conservation value
> 10.0 to 15.0	Sites supporting at least one uncommon species, or several species of restricted distribution and/or a community of high taxon richness	Fairly high conservation value
> 15.0 to 20.0	Sites supporting several uncommon species, at least one of which may be nationally rare and/or a community of high taxon richness	High conservation value
> 20.0	Sites supporting several rarities, including species of national importance and/or a community of very high taxon richness	Very high conservation value

Appendix F Lotic-Invertebrate Index for Flow Evaluation (LIFE)

The Lotic-Invertebrate Index for Flow Evaluation (LIFE) provides an assessment of the impact of variable flows on benthic macroinvertebrate communities. Under the assessment, individual species of aquatic macroinvertebrates are assigned to a flow group varying from I to VI, as detailed on the Table C1 below. The LIFE score for a macroinvertebrate sample is then derived (mean of individual scores) from individual species scores and abundances, as detailed on the Table C3 below. LIFE scores for a macroinvertebrate sample ranges from 1 to 12, where highest scores describe communities adapted to rapid flows.

Table F1: Flow groups used to derive LIFE scores (from Extence, Balbi and Chadd, 1999)

LIFE score Group	Description	Mean current velocity
I	Taxa primarily associated with rapid flows	Typically > 100 $cm.s^{-1}$
II	Taxa primarily associated with moderate to fast flows	Typically 20 to 100 $cm.s^{-1}$
III	Taxa primarily associated with slow or sluggish flows	Typically < 20 $cm.s^{-1}$
IV	Taxa primarily associated with (usually slow) and standing waters	
V	Taxa primarily associated with standing waters	
VI	Taxa frequently associated with drying or drought impacted sites	

Table F2: Abundance categories used to derive LIFE scores (from Extence, Balbi and Chadd, 1999)

Abundance catergory	Description
A	1 to 9
B	10 to 99
C	100 to 999
D	1000 to 9999
E	> 10000

Table F4: A guide to interpreting LIFE scores (from Extence, Balbi and Chadd, 1999)

Flow groups	Abundance categories			
	A	B	C	D/E
I	9	10	11	12
II	8	9	10	11
III	7	7	7	7
IV	6	5	4	3
V	5	4	3	2
VI	4	3	2	1