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1. SUMMARY

Utilising a project team composed of experts from Bournemouth University Global Environmental Solutions (BUG) and the Freshwater Biological Association (FBA), this document reports the findings of pre-and post-restoration biodiversity surveys of New Forest Streams carried out in April and October 2015, and March and May 2016.

The surveys were commissioned to provide pre-restoration baseline assessments together with post-restoration assessments, against which to assess the success of hydromorphological stream restoration work in restoring ecological quality.

The surveys were also tasked with highlighting any rare species afforded conservation protection under the following designations:

- Schedule 5 Wildlife and Countryside Act (1981) Species
- Red Data Book Species
- UK BAP Priority Species
- Nationally and Regionally Scarce Species

This document reports the findings of the 2015 and 2016 surveys (up to and including May 2016):

- With the exception of some temporarily reduced biotic index results, possibly due to recent tree felling, the four groups of freshwater stream sites surveyed were in generally good biological condition prior to river restoration work.
- A wide range of freshwater macroinvertebrate species have been recorded, with each group of sites having its own distinctive community.
- Two fish species and two invertebrate species with conservation designations have been recorded.
- These surveys have compiled important baseline information on the spring 2015 and 2016 pre- and/or post-restoration physical stream type of each watercourse, their macroinvertebrate communities, and their biological condition compared to reference condition predictions.
- Initial post restoration results from three sites show notable deterioration in the biological condition and conservation value of the restored sites. These surveys were undertaken shortly after the restoration work was completed at a time when macroinvertebrate communities had not had time to re-establish to pre-restoration levels.
- Further post-restoration monitoring is recommended to assess recovery of the restored sites to ensure they reach and exceed their pre-restoration biological conditions and conservation value.
- This work exemplifies best-practice on the part of the Forestry Commission in commissioning pre-restoration surveys to properly understand the ecological outcomes associated with its work.

2. INTRODUCTION

Geo- and hydromorphological restoration of flowing water bodies are widely regarded as being of positive environmental benefit; however, this can be difficult to justify to local land owners, interest groups and other organisations without sound supporting evidence. This project has been designed to focus specifically on freshwater macroinvertebrate communities as an indicator of ecological quality and to detect whether any temporal changes in community structure (positive or negative) can be attributed to the physical re-engineering of stream profiles.

During an initial scoping exercise a total of five New Forest sites were assessed for their suitability to acquire pre-restoration baseline data. Due to the ephemeral nature of one site at Amberslade, the stream bed was found to be dry upon pre-restoration inspection visit and, thus, this site was dropped from the survey. Of the remaining four sites, surveys were conducted in accordance with the RIVPACS 3-minute kick-sampling protocol. To elucidate treatment effects from ambient conditions several additional control sites were also included within the survey design.

Utilising a project team composed of experts from BUG and the FBA, this document reports the findings of the pre-and post-restoration biodiversity surveys of New Forest Streams carried out in April and October 2015, and March and May 2016. It is important to note that Harvestslade was the only site where restoration works had been completed in advance of the spring 2016 surveys. Due to challenging ground conditions, only partial restoration had been achieved at Cowley's Heath (East and West sites) and no change had occurred at Pondhead or Wootton.

2.1 Aims and objectives

The specific aims and objectives of this project are as follows:

- Provide a pre-restoration biodiversity audit of New Forest Streams to highlight any rare species afforded conservation protection under the following designations:
  - Schedule 5 Wildlife and Countryside Act (1981) Species
  - Red Data Book Species
  - UK BAP Priority Species
  - Nationally and Regionally Scarce Species
- Provide a pre-restoration baseline of ecological quality in line with Water Framework Directive (WFD) best practice methodology.
- Undertake repeat post-restoration surveys to determine initial ecological gains/losses attributable to the in-stream restoration works.

Note: This work is delivered under call off 10 under the Specialist Ecological Surveys Framework (Ref. No. 304/NF/13/751).

3. METHODOLOGY

3.1 Walkover survey and site selection

A walkover survey was used to assess the suitability of the streams for subsequent macroinvertebrate kick sampling; specifically the accessibility of each potential watercourse, their approximate size and water depth, their permanence, and current presence of water in the channel.

In addition, and to facilitate easy return to the selected sampling locations, GPS readings and site photographs were also taken. The walkover survey was carried out by Adrian Pinder (BUG) and Nick Wardlaw (FC) on 22 April 2015. The spatial distribution of the sites is provided in Figure 3.1.

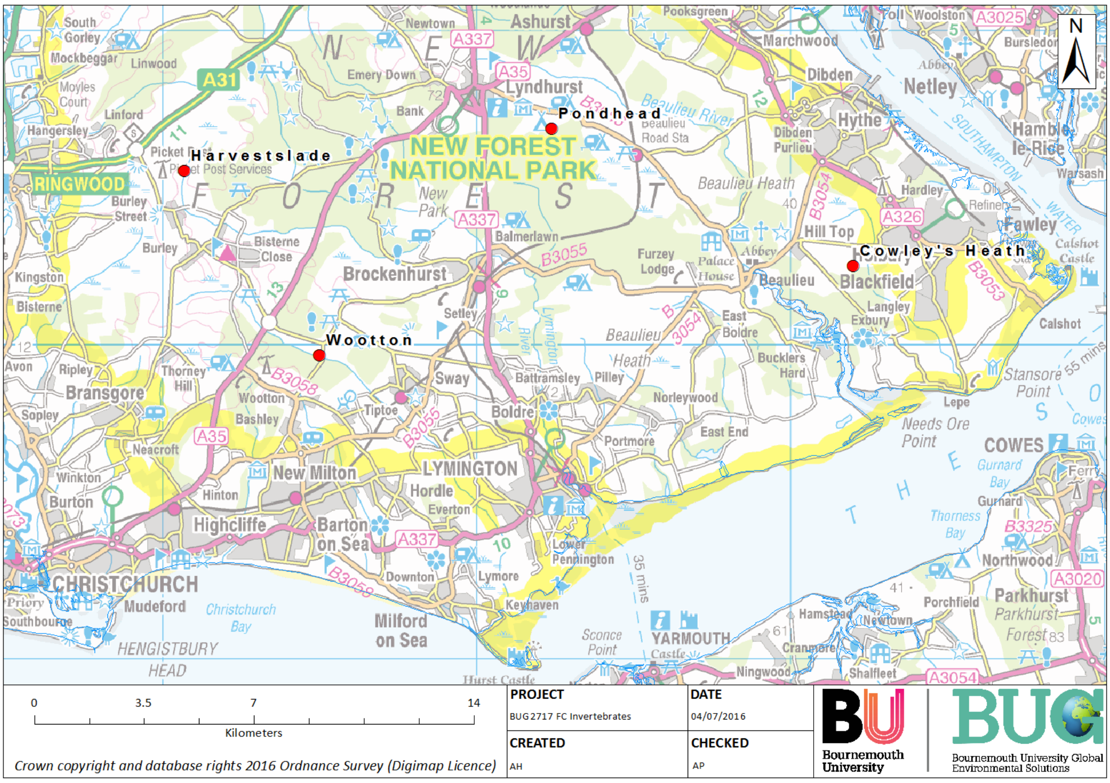

Figure 3.1. Location of restoration sites.

With the exception of Amberslade, an ephemeral stream which had already run dry, suitable survey sites were identified at Cowley's Heath, Pondhead and Harvestslade. With Amberslade omitted from the survey, BUG and FC agreed the spatial survey design summarised in Table 3.1.

Additional sites at Wootton were also identified later in 2015. These are also shown in Table 3.1, together with the dates each site was sampled. Exact grid references of the biological samples are shown in Table 4.1.

Table 3.1. Summary of selected sample sites and dates sampled.

Locality	Site code	NGR	Treatment or Control	Date sampled			
				27Apr15	27Oct15	11Mar16	17May16
Cowley's Heath	East 1	SU4199802523	Treatment	✓	-	-	✓
	West 1	SU4141002443	Treatment	✓	-	-	✓
	Control 1	SU4239502523	Control	✓	-	-	✓
Pondhead	U/S 1	SU3239206901	Treatment	✓	-	-	✓
	D/S 2	SU3244606955	Treatment	✓	-	-	✓
	Control 1	SU3198006897	Control	✓	-	-	✓
Harvestslade	H1	SU2069705553	Treatment	✓	-	-	-
	New Ch.	SU2067505568	Treatment	-	-	-	✓
Wootton	Ph.1 S1	SZ2499599678	Treatment	-	✓	✓	-
	Ph.1 S2	SU2334700378	Treatment	-	✓	✓	-
	Ph.2	SZ2638398821	Treatment	-	✓	✓	-

3.2 Macroinvertebrate survey

The first macroinvertebrate survey was carried out by Adrian Pinder (BUG) and John Davy-Bowker (FBA) on 27th April 2015. Further repeat surveys were carried out on 27th October 2015, 11th March 2016 and 17th May 2016.

Macroinvertebrate samples were collected in accordance with the standard Environment Agency (EA) three-minute kick sampling procedure using a 1 mm mesh long-handled pond net (set out in '*Procedures For Collecting and Analysing Macroinvertebrate Samples*". BT001 3.0, Third Issue; 1991) and by the procedure for collecting and analysing macroinvertebrate samples for RIVPACS (Murray-Bligh *et al.* 1992). This ensured that a representative range of mesohabitats were sampled in proportion to their occurrence to facilitate spatial and temporal comparisons.

At each sampling site, a basic suite of physicochemical parameters (pH, temperature, conductivity, dissolved oxygen) and general habitat characteristics (water velocity category, width, depth and substratum composition) were recorded on standard RIVPACS/RICT '*Sample Area'* forms. These variables are useful both for describing the general sampling site characteristics, and also as predictor variables for running the RIVPACS (River Invertebrate and Prediction and Classification System) model (see Section 3.2.4).

All samples were accompanied by a confirmatory site photograph (**Appendix II**), GPS reading, and sampling site sketch map to facilitate subsequent return to the same location for re-survey work. In addition, the presence of aquatic macrophytes and other species observed incidentally during the macroinvertebrate sampling (e.g. fish) were also recorded.

All sampling equipment, chemical analysis probes and personal protective equipment had been thoroughly dried prior to visiting the New Forest and all equipment was checked for foreign species, as recommended by the GB Non-Native Species Secretariat '*Check, Clean, Dry*' campaign (GB NNSS

2015). As an additional precaution, all equipment that might come into contact with the sampling sites was sprayed with '*Virkon® S'* (DuPont™) a powerful broad-spectrum virucidal, bactericidal and fungicidal disinfectant prior to visiting the sampling sites to prevent the transfer of crayfish plague or other pathogens.

Macroinvertebrate samples were fixed at the riverbank using 4% formaldehyde. The use of formaldehyde is considered superior to 70% Industrial Methylated Spirits due to its more rapid and thorough fixation of organic matter and the greatly enhanced shelf life of the samples and the invertebrate specimens they contain. Sample pots were clearly labelled both internally, using pencil and waterproof paper labels, and externally using a waterproof bullet marker. Samples were returned to the laboratory for processing (bankside analysis being considered inappropriate for species level identification).

3.2.1 Laboratory Sample Processing

Macroinvertebrate samples were sorted, identified and enumerated following the procedures set out in '*Procedures For Collecting and Analysing Macroinvertebrate Samples"*. BT001 3.0, Third Issue; 1991) and by the procedure for collecting and analysing macroinvertebrate samples for RIVPACS (Murray-Bligh *et al.* 1992). Samples were processed to species-level, specifically RIVPACS Taxonomic Level '*TL5'* (Davy-Bowker *et al.* 2010), and numerical abundances of all taxa were estimated and recorded on laboratory sample data sheets.

Examination of picked invertebrates was made using a binocular/compound microscope, as required. Appropriate taxonomic keys were used for identification, making reference to FBA reference collections, where necessary. All samples were reconstituted (put back into their original sample pots and re-preserved) and retained for subsequent quality assurance purposes. Where any specimens were retained for addition to FBA reference collections, this was clearly marked on the laboratory sample analysis sheets. All sample analyses were carried out by the FBA (J. Davy-Bowker, FBA River Laboratory; M. Fletcher and S. Pawley, FBA Windermere).

3.2.2 Data Entry and Validation

Macroinvertebrate data from sample analysis laboratory datasheets was entered into an FBA designed Microsoft® Access data entry database. Following data entry, sample validation reports (lists of entered species names and abundances) were printed out and manual data validation checks were performed to ensure that no errors arose due to data entry. Any data entry errors were corrected and the validation process was repeated until the data were error-free. Following validation, data were then exported for the calculation of biotic indices and the assignment of conservation designations (see below).

3.2.3 Calculation of Biotic Indices

Data were imported into an FBA designed Microsoft® Access database containing queries for the automatic calculation of a wide range of freshwater macroinvertebrate biotic indices at family and/or species levels.

Further information on the biotic indices is provided below (commonly used index abbreviations, the full name of each index, sources/references and typical types of environmental stress described by each index):

- **BMWP, NTAXA, ASPT**

Name: Biological Monitoring Work Party

Reference(s): Armitage *et al.* 1983; Hawkes 1997

Stressor described: General degradation

- **WHPT, NTAXA, ASPT**

Name: Whalley, Hawkes, Paisley, Trigg

Reference(s): UKTAG 2014

Stressor described: General degradation

- **AWIC(sp) Murphy**

Name: Acid Water Indicator Community

Reference(s): Murphy *et al.* 2013

Stressor describe: Acidity/acidification stress

- **WFD AWIC(sp) McFarland**

Name: *WFD Acid Water Indicator Community*

Reference(s): McFarland 2010; UKTAG 2014

Stressor described: Acidity/acidification stress

- **LIFE(sp)**

Name: Lotic-invertebrate Index for Flow Evaluation

Reference(s): *Extence et al. 1999*

Stressor described: Flow stress

- **PSI(sp)**

Name: Proportion of Sediment-sensitive Invertebrates

Reference(s): *Extence et al. 2013*

Stressor described: Sedimentation stress

- **SPEAR(sp)%**

Name: Species At Risk

Reference(s): Beketov *et al. 2008*

Stressor described: Pesticide stress

- **CCI**

Name: Community Conservation Index

Reference(s): Chadd and Extence 2004

Stressor described: Conservation value

3.2.4 RIVPACS Assessments

In addition to the calculation of observed biotic indices for the macroinvertebrate samples (described above) it was useful to also be able to compare these observed indices to a benchmark or reference value for that type of stream. This type of comparison in running waters is commonly achieved in the United Kingdom by using RIVPACS predictive models.

RIVPACS (River Invertebrate Prediction and Classification System) is a predictive model that uses environmental variables such as stream width and depth, distance from source, altitude, etc. to predict the reference (undisturbed) values of a range of biotic indices (Wright *et al.* 1997; Clarke *et al,* 2003). RIVPACS is based on a dataset of 685 GB reference sites that are grouped into similar 'end groups' whose environmental variables are similar to each other. Predicted biotic indices for test samples (the New Forest samples) are obtained by gathering the same environmental variables (environmental predictor variables) and running these through the model. Each test sample is assigned a probability of RIVPACS end group membership based on its environmental variables. The biotic index values of the reference sites in the various end groups then contribute to the predicted index values for the test sample. Rather than drawing the prediction solely from one end group of reference sites, the predictions of reference condition biotic indices are derived by the model as a weighted average depending upon probability of end group membership (Clarke *et al.* 2011).

The RIVPACS model used was the current RIVPACS IV model (Davy-Bowker *et al*. 2008) within the RICT (River Invertebrate Classification Tool) software – a web based tool containing the RIVPACS models:

www.sepa.org.uk/environment/water/classification/river-invertebrates-classification-tool/

RIVPACS IV is the current RIVPACS model used by the Environment Agency and others to perform Water Framework Directive (Council of the European Communities 2000) quality assessments and is regarded as the industry standard for assessing the biological condition of running waters.

The observed values of the biotic indices from the New Forest samples were then compared to the RIVPACS predicted expected values of the indices by the calculation of observed/expected ratios. For example, an observed biotic index value of 75 would be divided by an expected value of the same index, of say 85, to give an observed/expected (O/E) ratio of 0.882. An O/E ratio of greater than 1.0 indicates that a test sample has exceeded its predicted biotic index value (it is better than similar reference condition sites in the model); an O/E ratio of slightly below 1.0 (e.g. 0.882) indicates that a test sample is close to its predicted index value and is, therefore, only minimally impacted; an O/E ratio close to zero indicates that a test sample falls a long way short of its predicted biotic index value and it is, therefore, heavily stressed or degraded.

3.2.5 Assignment of Conservation Designations

In addition to describing the overall community-level conservation status of the samples by calculating the CCI index (see Section 3.2.3 above), species present in the macroinvertebrate samples were also individually assessed for their conservation value by assigning rarity and threat conservation designations. Current designations were obtained from the Joint Nature Conservation Committee (JNCC) website (http://jncc.defra.gov.uk/page-3408; file: Taxon_designations_20140822.zip; last updated on the 1st August 2014). This included conservation designations for any species that have been assigned some form of rarity, threat or legal status in Great Britain or the UK, specifically:

- Bern Convention (Appendices 1, 2 and 3)
- Biodiversity Action Plan (BAP) UK priority species list
- EC CITES (Annexes A, B, C and D)
- Global Red list status
- Nationally Rare/Scarce (Not based on IUCN criteria)
- Nationally Scarce and Nationally Rare Species (Also with an IUCN status)
- National Red Lists (This includes red listings based on pre-1994, 1994 and 2001 IUCN guidelines)
- Species of principal importance in England, Scotland, Wales and North Ireland (NERC section 41 and 42 lists, Scottish Biodiversity
- The Wildlife and Countryside Act 1981 (Schedule 1, 5 and 8)

4. RESULTS AND DISCUSSION

4.1 Physico-chemical variables

The physicochemical variables for the twenty New Forest macroinvertebrate sampling sites in April and October 2015, and March and May 2016 are shown in Table 4.1**.**

All of the sites were at low altitudes (20-61m above sea level) and had relatively low slopes (4 – 25m altitude change per km of river). All of the sites had low discharge category (≤0.31 cubic metres per second); low velocity category (≤25 cm s^{-1}); and low distances to source (≤7.0 km). River widths were narrow (≤5.2 m) and mean water depths were shallow ($\bar{x}$ 14.15 cm). These physical characteristics are typical of New Forest streams, where all river systems are less than 30 km from source to mouth and have sources at altitudes less than 125 m (Langford *et al.* 2010).

The stream substratum at all sites was typically dominated by pebbles and gravel, although two of the sites (Cowleys Heath East 1 and West 1) had appreciable percentage cover of sand, silt and clay (20-35 %). Substratum composition is a powerful driver of macroinvertebrate community composition (Murphy & Davy-Bowker 2005) and is also likely to be a factor that may change as a result of restoration work.

The pre-restoration baseline data provide a useful benchmark against which to assess changes in substratum composition due to restoration work. At Cowleys Heath East 1 the substratum shifted from pre-restoration dominance of pebbles/gravel (40 percent) and with silt/clay (35 percent), to post-restoration dominance of larger substratum comprising 85 percent pebbles/gravel and a reduction to 1 percent silt/clay. This change was due to the augmentation of course grained stones in the river channel as part of the restoration work.

A marked change in substratum composition was also noted at Harvestslade. At Harvestslade the original (hence forth described as 'old') river channel was filled in and an old meander re-introduced. The old channel had 85 percent pebbles/gravel and very little (5 percent) silt/clay. The new channel, in contrast, had a much lower percentage of pebbles/gravel (15 percent) and much more silt/clay (45 percent). Of this latter figure, almost all of the 45 percent silt and clay was in the form of clay (a substratum type often associated with low macroinvertebrate diversity and abundance).

In describing the changes in substratum composition due to river restoration, it is also important to note that both schemes were assessed very early in the re-establishment phase. The substratum percentages recorded may change in due course, as natural hydrological processes such as floods and spates have the potential to mobilise the substratum and sort and redistribute it within the channel

Finally, during the spring 2016 surveys, sampling sites generally had circum-neutral pH ranging between 6.5 and 8.25 and were, thus, not acidic. Dissolved oxygen was generally elevated ($\bar{x}$ 91.91 %; 9.94 mg l^{-1}), and water clarity was generally good; although, most sites had a faint brown water colouration. A notable exception was the Harvestslade new channel which had a noticeable dark brown water colouration.

Table 4.1. Physico-chemical variables for the April and October 2015, and March and May 2016, RIVPACS samples. Origin of variables: [1]measured *in situ* and recorded on RIVPACS sample area form; [2]recorded *in situ* from handheld GPS; [3]derived from 1:50,000 Ordnance Survey map; [4]derived from discharge category map; [5]measured *in situ* with YSI hand-held meter).

	Cowleys Heath						Pondhead						Harvestslade		Wootton					
	Control 1		East 1		West 1		Control 1		U/S 1		D/S 2		H1	NC	Phase 1 Site 1		Phase 1 Site 2		Phase 2	
[1]Sample date	27 Apr 2015	17 May 2016	27 Apr 2015	17 May 2016	27 Apr 2015	17 May 2016	27 Apr 2015	17 May 2016	27 Apr 2015	17 May 2016	27 Apr 2015	17 May 2016	27 Apr 2015	17 May 2016	27 Oct 2015	11 Mar 2016	27 Oct 2015	11 Mar 2016	27 Oct 2015	11 Mar 2016
[1]Sample time of day	10:30	11:10	11:20	12:00	12:15	13:00	14:00	14:00	14:40	14:30	15:10	15:30	16:45	17:00	10:00	11:33	11:00	10:45	12:45	12:44
[1]Method	K/S	K/S	K/S	K/S	K/S	K/S	K/S	K/S	K/S	K/S	K/S	K/S	K/S	K/S	K/S	K/S	K/S	K/S	K/S	K/S
[1]Duration	3min	3min	3min	3min	3min	3min	3min	3min	3min	3min	3min	3min	3min	3min	3min	3min	3min	3min	3min	3min
[1]Kick Sampler	JDB	JDB	JDB	JDB	JDB	JDB	JDB	JDB	JDB	JDB	JDB	JDB	JDB	JDB	JDB	JDB	JDB	JDB	JDB	JDB
[1]Recorder	AP	AP	AP	AP	AP	AP	AP	AP	AP	AP	AP	AP	AP	AP	WOB	JP	WOB	JP	WOB	JP
[2]NGR	SU 42392 02534	SU 42392 02534	SU 42006 02508	SU 42006 02508	SU 41418 02443	SU 41418 02443	SU 31990 06909	SU 31987 06911	SU 32392 06903	SU 32392 06903	SU 32446 06961	SU 32446 06961	SU 20697 05556	SU 20675 05568	SZ 24995 99678	SZ 24995 99678	SU 23347 00378	SU 23347 00378	SZ 26383 98821	SZ 26383 98821
[2]Altitude (m)	24	24	20	20	21	21	23	23	23	23	24	24	61	61	27	27	34	34	23	23
[3]Slope ($m\ km^{-1}$)	5	5	25	25	11	11	4	4	5	5	5	5	7	7	4	4	4	4	4	4
[4]Discharge (category)	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
[1]Velocity (category)	2	2	1	1	1	1	2	1	1	1	1	1	2	1	1	1	1	1	2	2
[3]Distance from source (km)	2.3	2.3	0.2	0.2	0.5	0.5	3.5	3.5	2.5	2.5	2.6	2.6	1.1	1.1	5.6	5.6	4.0	4.0	7.0	7.0
[1]Mean width (m)	2.7	2.8	0.5	0.6	1.2	1.7	2.2	2.7	2.3	2.5	2.8	2.1	0.9	2.2	5.0	5.2	3.0	2.5	3.7	3.2
[1]Depth at ¼ width (cm)	7	6	3	5	4	8	4	6	11	14	15	4	5	29	12	10	47	55	16	24
[1]Depth at ½ width (cm)	9	11	17	3	27	7	6	4	13	14	12	4	7	6	10	18	37	49	17	21
[1]Depth at ¾ width (cm)	9	5	5	4	11	5	10	4	14	20	3	14	9	28	9	14	29	35	20	24
[1]Mean depth (cm)	8.3	7.3	8.3	4.0	14	6.7	6.7	4.7	12.7	16.0	10	7.3	7	21.0	10.3	14.0	37.7	46.3	17.7	23.0
[1]Boulders and cobbles (%)	0	0	0	5	0	5	0	0	0	0	0	0	5	40	0	0	0	0	0	0
[1]Pebbles and gravel (%)	83	75	40	85	60	92	89	75	85	80	85	75	85	15	85	95	80	90	75	80
[1]Sand (%)	15	20	25	9	20	3	10	23	5	10	10	5	5	0	5	5	10	10	15	18

	Cowleys Heath						Pondhead						Harvestslade		Wootton					
	Control 1		East 1		West 1		Control 1		U/S 1		D/S 2		H1	NC	Phase 1 Site 1		Phase 1 Site 2		Phase 2	
[1]Silt and clay (%)	2	5	35	1	20	0	1	2	10	10	5	20	5	45	10	0	10	0	10	2
[5]pH	6.5	8.1	6.8	7.4	6.8	7.3	6.7	7.3	6.7	7.3	6.7	7.3	7.0	7.7	8.25	7.59	7.65	7.22	7.13	7.27
[5]Temperature (°C)	9.4	11.9	16.6	16.2	11.8	16.3	10.6	12.5	11.4	13.2	11.4	13.2	13.0	15.9	10.8	7.1	11.0	7.0	11.6	7.4
[5]Conductivity (µs)	234.0	165.2	217.6	123.0	170.3	96.9	281.0	243.1	273.0	218.7	273.0	218.7	109.0	69.6	133.9	103.4	111.5	90.2	117.9	102.0
[5]Dissolved Oxygen (%)	122.4	92.2	90.0	40.3	122.0	71.1	111.2	79.6	122.5	79.2	122.5	79.2	119.0	76.1	86.7	87.1	81.7	85.5	86.0	83.8
[5]Dissolved Oxygen (mg l^{-1})	13.95	9.94	8.93	3.98	12.27	6.96	12.34	8.47	13.38	8.25	13.38	8.25	12.60	7.55	9.59	10.42	8.94	10.27	9.38	10.01
[1]Water clarity	Clear	Clear	Clear	Clear	Clear	Clear	Clear	Cloudy	Clear	Cloudy	Clear	Cloudy	Clear	Clear	Clear	Clear	Clear	Clean	Clear	Clear
[1]Water colour	Faint	Faint	Faint	Faint	Faint	Faint	Faint	Slight	Colour	Slight	Colour	Slight	Faint	Dark Brown	Clear	Clear	Clear	Slight	Clear	Slight
[1]Algae cover (%)	0	0	0	0	0	10	0	0	0	0	0	<1	2	0	0	0	0	0	0	0
[1]Moss cover (%)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
[1]Higher plant cover (%)	0	0	<1	0	0	0	0	0	<1	0	<1	0	<1	0	0	0	<1	<1	0	0
[1]Total cover (%)	0	0	<1	0	0	10	0	0	<1	0	<1	<1	2	0	0	0	<1	<1	0	0
[1]Detritus	Present	Present	Present	Present	Present	Present	Present	Present	Present	Present	Present	Present	Present	Absent	Present	Present	Present	Present	Present	Absent
[1]Other information	Public access	Pony access	Deep cut. Clear fell	Very shallow. Heather from bales in river	Clear fell	Fresh gravel. Algae increase	-	Site moved due to log jam	-	-	-	-	-	New channel. Fauna sparse	High public access. Lots of leaf litter	Public access. Highly tramp-led	Horses drinking from bank. Lots of leaf litter	Rained heavily 2 days ago. River appears normal today.	Appears to be large pumping station nearby	Appears to be large pumping station nearby

4.2 Macroinvertebrate species and conservation designations

The species found in all twenty New Forest macroinvertebrate samples taken on 27th April and 27th October 2015, and 11th March and 17th May 2016 are shown in Table 4.2**.**

The twenty New Forest samples yielded a rich fauna of macroinvertebrate species, with good species richness overall and, in particular, across several macroinvertebrate orders; most especially, the aquatic Coleoptera (Water Beetles), Plecoptera (Stoneflies), and Trichoptera (Caddis Flies).

The four groups of sites (Cowleys Heath, Pondhead, Harvestslade and Wootton) each had their own characteristic community with differing proportions of species from different invertebrate orders.

The three Cowleys Heath sites (including the control site) had a pre-restoration average species richness (excluding those taxa that could not be identified to species) of 16.0 species (min. 15; max. 17) and were characterised by high species richness of aquatic Coleoptera (7 species recorded across all three sites).

Following restoration at Cowleys Heath East, species richness fell from 16 to 11. Following restoration at Cowleys Heath West, a particularly marked reduction in species richness was recorded, falling from 15 species to 3.

The three Pondhead sites sampled in April 2015 had an average species richness of 27.7 species (min. 24; max. 33) and had high species richness of Plecoptera and Trichoptera (6 and 14 species recorded respectively). No restoration work had been undertaken at these sites when the follow up survey was carried out in May 2016. Species richness in this second set of samples was broadly similar (average species richness 25.0; min. 19; max. 29).

The single Harvestslade site was the least species rich of all the sites sampled with only 8 species recorded in total, compared to the average species richness across the other six sites of 21.8. Following filling in of this old channel, the species richness recorded at the new channel on 17th May 2016 was very low, with only two species recorded. It should be noted that this new channel is in the very early stages of re-colonisation and subsequent monitoring will be needed to determine if the new channel can, in time, reach and surpass the diversity of the original channel.

The three Wootton sites have been sampled twice (October 2015 and March 2016). No restoration work has been carried out at Wootton and average species richness across all six samples was 22.5 species (min 16; max. 26). The Wootton sites were rich in Ephemeroptera, Plecoptera and Trichoptera (5, 7 and 11 species recorded respectively).

Two rare invertebrates were recorded in the macroinvertebrate samples. Firstly the Water Beetle *Helophorus (Trichohelophorus) alternans* Gené 1836 was found at Cowleys Heath East 1 in the April 2015 macroinvertebrate samples. *H. alternans* has a JNCC recognised conservation status and is designated as Nationally Scare (Table 4.3) occurring in only 16-100 hectads in Great Britain (Foster, 2010). A second rare species of water beetle *Hydrochus angustatus Germar 1824* was found in the Wootton Phase 1, Site 2 sample taken on 11th March 2016. *H. angustatus* is also designated as Nationally Scare (Table 4.3) occurring in only 16-100 hectads in Great Britain (Foster, 2010). Both species were recorded as single individuals and their continued survival at these sites is clearly desirable. Fish species with conservation designations (Section 4.3) are also summarised in Table 4.3.

Table 4.2. Macroinvertebrate species composition and abundance (April and October 2015; and March and May 2016 RIVPACS samples).

	Cowleys Heath						Pondhead						Harvestslade		Wootton					
	C 1	C 1	E1	E1	W1	W1	C 1	C 1	US 1	US 1	DS 2	DS 2	H1	NC	P1 S1	P1 S1	P1 S2	P1 S2	P2	P2
	27 Apr 2015	17 May 2016	27 Apr 2015	17 May 2016	27 Apr 2015	17 May 2016	27 Apr 2015	17 May 2016	27 Apr 2015	17 May 2016	27 Apr 2015	17 May 2016	27 Apr 2015	17 May 2016	27 Oct 2015	11 Mar 2016	27 Oct 2015	11 Mar 2016	27 Oct 2015	11 Mar 2016
Sponges																				
Spongillidae																	1			
Flatworms																				
Polycelis felina (Dalyell, 1814)				1			44	60				1			2	4	4	8	2	12
Dendrocoelum lacteum (O.F.Müller, 1774)							1	3												
Horsehair Worms																				
Nematomorpha															2					
Nematodes																				
Nematoda																		1		
Snails																				
Potamopyrgus antipodarum (J.E. Gray, 1843)	388	112	4	2	8											12	1		4	1
Lymnaeidae sp.						1														
Stagnicola palustris (O.F. Müller, 1774)				2																
Radix balthica (Linnaeus, 1758)			2		4		4		2	1		3								1
Planorbis (Planorbis) carinatus (O.F. Müller, 1774)							1													
Bathyomphalus contortus (Linnaeus, 1758)																		1		1
Gyraulus (Gyraulus) albus (O.F. Müller, 1774)								1												
Ancylus fluviatilis O.F. Müller, 1774	20						28	2	28	16	12	8			112	64	12	36		6
Bivalves																				
Sphaeriidae sp.									4											
Sphaerium sp.								5		4		4								
Pisidium sp.	8				4	1	228	132	56	52	36	16		8	20	16	60	40		32

	Cowleys Heath						Pondhead						Harvestslade		Wootton					
	C 1	C 1	E1	E1	W1	W1	C 1	C 1	US 1	US 1	DS 2	DS 2	H1	NC	P1 S1	P1 S1	P1 S2	P1 S2	P2	P2
	27 Apr 2015	17 May 2016	27 Apr 2015	17 May 2016	27 Apr 2015	17 May 2016	27 Apr 2015	17 May 2016	27 Apr 2015	17 May 2016	27 Apr 2015	17 May 2016	27 Apr 2015	17 May 2016	27 Oct 2015	11 Mar 2016	27 Oct 2015	11 Mar 2016	27 Oct 2015	11 Mar 2016
Worms																				
Oligochaeta	202	184	100	188	124	244	264	124	212	196	388	220	24	56	220	24	60	28	204	112
Leeches																				
Piscicola geometra (Linnaeus, 1761)										3	1	3								
Glossiphoniidae sp.						1														
Theromyzon tessulatum (O.F.Müller, 1774)											1									
Glossiphonia complanata (Linnaeus, 1758)	2	8						16	8	5	6	8					2	8	1	2
Helobdella stagnalis (Linnaeus, 1758)															12	2	2	2		
Erpobdella sp.											1									
Erpobdella octoculata (Linnaeus, 1758)							6	6	12	5	4	3			4			1		1
Water Mites																				
Hydracarina	10	2		1		1	1	1	4	1	3	1	8			1				
Ostracods																				
Ostracoda sp.				1											2		1			
Crustaceans																				
Asellus sp.																	4			
Asellus aquaticus (Linnaeus, 1758)		3	2				24	20	4	144	16	48		1		2				1
Proasellus meridianus (Racovitza, 1919)				40															12	
Gammarus sp.					80						80									
Gammarus pulex (Linnaeus, 1758)	124	220	9	48	36	44	1092	2888	40	244	16	164			852	52	272	112	340	144
Niphargus aquilex Schiodte, 1855													1							
Springtails																				
Collembola sp.				2				1												
Mayflies																				

	Cowleys Heath						Pondhead						Harvestslade		Wootton					
	C 1	C 1	E1	E1	W1	W1	C 1	C 1	US 1	US 1	DS 2	DS 2	H1	NC	P1 S1	P1 S1	P1 S2	P1 S2	P2	P2
	27 Apr 2015	17 May 2016	27 Apr 2015	17 May 2016	27 Apr 2015	17 May 2016	27 Apr 2015	17 May 2016	27 Apr 2015	17 May 2016	27 Apr 2015	17 May 2016	27 Apr 2015	17 May 2016	27 Oct 2015	11 Mar 2016	27 Oct 2015	11 Mar 2016	27 Oct 2015	11 Mar 2016
Baetidae sp.	2	2																		
Baetis rhodani (Pictet, 1843-1845)	54	20			2		20	2		4	16	152			8	20		4		7
Procloeon pennulatum (Eaton, 1870)			2																	
Rhithrogena sp.															4	7				
Leptophlebiidae sp.		1																		
Leptophlebia marginata (Linnaeus, 1767)																		3		
Paraleptophlebia sp.																			1	
Paraleptophlebia submarginata (Stephens, 1835)															12	8	12	1		5
Habrophlebia fusca (Curtis, 1834)			20	4	5		60		632	556	544	212				8		3		
Ephemera danica Müller, 1764							8	9	232	472	16	12								
Serratella ignita (Poda, 1761)		28								32		28			1					
Stoneflies																				
Amphinemura sp.		1																		
Amphinemura standfussi Ris, 1902	1								4		2	11								
Amphinemura sulcicollis (Stephens, 1836)			1				5				8									
Nemoura avicularis Morton, 1894															24	2	80	4	20	4
Nemoura cinerea (Retzius, 1783)			20	1	8					1	4	2	1							
Leuctra sp.	2	24	64	9	388	24	16	1	8	64	8	172	84		12		4		12	2
Leuctra fusca (Linnaeus, 1758)		16													4		3		8	
Leuctra hippopus Kempny, 1899																3		2		
Leuctra inermis Kempny, 1899														40						
Leuctra nigra (Olivier, 1811)					1										4			1		
Capnia bifrons (Newman, 1839)											1					1				1
Isoperla grammatica (Poda, 1761)											3	3				2				

	Cowleys Heath						Pondhead						Harvestslade		Wootton					
	C 1	C 1	E1	E1	W1	W1	C 1	C 1	US 1	US 1	DS 2	DS 2	H1	NC	P1 S1	P1 S1	P1 S2	P1 S2	P2	P2
	27 Apr 2015	17 May 2016	27 Apr 2015	17 May 2016	27 Apr 2015	17 May 2016	27 Apr 2015	17 May 2016	27 Apr 2015	17 May 2016	27 Apr 2015	17 May 2016	27 Apr 2015	17 May 2016	27 Oct 2015	11 Mar 2016	27 Oct 2015	11 Mar 2016	27 Oct 2015	11 Mar 2016
Siphonoperla torrentium (Pictet, 1841)	24	6	12		76				4		12	1	32			15	1	4	4	9
Dragonflies and Damselflies																				
Zygoptera sp.																				1
Calopteryx sp.	2	1			2															
Calopteryx virgo (Linnaeus, 1758)									1	1	2				1					
Anisoptera sp.			10																	
Cordulegaster boltonii (Donovan, 1807)			2		3								5		1		2		1	1
Libellulidae sp.						1														
Sympetrum sp.				2																
True Bugs																				
Veliidae sp.											1	1								
Velia sp.	2			3																1
Gerris sp.				1																
Gerris lacustris (Linnaeus, 1758)			1			1														
Aquarius najas (DeGeer, 1773)		1														1	16	1		1
Nepa cinerea Linnaeus, 1758								1												
Notonecta sp.				1		1														
Water Beetles																				
Dytiscidae sp.			1			2				2										
Hydroporus memnonius Nicolai, 1822				1																
Hydroporus tessellatus (Drapiez, 1819)				1																
Orectochilus villosus (O.F. Müller, 1776)	2	1					1		4		3				12	3	3	2	20	7
Helophorus (Trichohelophorus) alternans Gené, 1836			1																	
Helophorus (Rhopalohelophorus) brevipalpis Bedel, 1881													1							

	Cowleys Heath						Pondhead						Harvestslade		Wootton					
	C 1	C 1	E1	E1	W1	W1	C 1	C 1	US 1	US 1	DS 2	DS 2	H1	NC	P1 S1	P1 S1	P1 S2	P1 S2	P2	P2
	27 Apr 2015	17 May 2016	27 Apr 2015	17 May 2016	27 Apr 2015	17 May 2016	27 Apr 2015	17 May 2016	27 Apr 2015	17 May 2016	27 Apr 2015	17 May 2016	27 Apr 2015	17 May 2016	27 Oct 2015	11 Mar 2016	27 Oct 2015	11 Mar 2016	27 Oct 2015	11 Mar 2016
Anacaena globulus (Paykull, 1829)	1		1																	
Anacaena limbata (Fabricius, 1792)																		2		
Anacaena lutescens (Stephens, 1829)			2	1			1													
Cercyon sp.				2																
Hydrochus angustatus Germar, 1824																		1		
Hydraena sp.															2					
Hydraena gracilis Germar, 1824															4					
Hydraena nigrita Germar, 1824		1	1																	
Hydraena riparia Kugelann, 1794																1				
Limnebius truncatellus (Thunberg, 1794)																				1
Elodes sp.							1	2			2	1						2		
Dryops sp.			2																	
Elmis aenea (Müller, 1806)							24	2	12	4	3	2			12	1	4		4	13
Limnius volckmari (Panzer, 1793)	52	25					76	12	80	48	88	60	4		56	13	28	61	232	124
Oulimnius sp.	6	2			1		16	1		4	28	8			24		40	3	24	
Oulimnius tuberculatus (Müller, 1806)	18	11					24	1	120	16	8	16			3	1				
Alderflies																				
Sialis lutaria (Linnaeus, 1758)										2	1						4			
Caddisflies																				
Rhyacophila dorsalis (Curtis, 1834)															2				2	1
Agapetus sp.	36	32			10		196	48	40	72	68	16			2	6		8	4	32
Oxyethira sp.			64	40	8	4				2										
Lype sp.								3			1	2					4	3		5
Polycentropodidae sp.													1							

	Cowleys Heath						Pondhead						Harvestslade		Wootton					
	C 1	C 1	E1	E1	W1	W1	C 1	C 1	US 1	US 1	DS 2	DS 2	H1	NC	P1 S1	P1 S1	P1 S2	P1 S2	P2	P2
	27 Apr 2015	17 May 2016	27 Apr 2015	17 May 2016	27 Apr 2015	17 May 2016	27 Apr 2015	17 May 2016	27 Apr 2015	17 May 2016	27 Apr 2015	17 May 2016	27 Apr 2015	17 May 2016	27 Oct 2015	11 Mar 2016	27 Oct 2015	11 Mar 2016	27 Oct 2015	11 Mar 2016
Cyrnus trimaculatus (Curtis, 1834)									1	3	1									
Plectrocnemia conspersa (Curtis, 1834)			9		4						4									
Polycentropus sp.															4	2				
Polycentropus irroratus (Curtis, 1835)	1	3							4	4	4	1					1	3		
Hydropsyche sp.					2															
Hydropsyche angustipennis (Curtis, 1834)							7					1								
Hydropsyche pellucidula (Curtis, 1834)															4	1				
Hydropsyche siltalai Döhler, 1963	20	8			8		3		4		20	7			4					1
Lepidostoma hirtum (Fabricius, 1775)	46	16			4		2	1	72	12	64	8	1		32	4	12	5	24	1
Limnephilidae sp.			2	3										1	1	2	16	16	4	1
Halesus sp.	3	1						2	2	16	8		1							
Micropterna group							1	1												
Potamophylax group	11	1			12		18	5	54	32	73	12	2				1			
Anabolia nervosa (Curtis, 1834)										4										
Glyphotaelius pellucidus (Retzius, 1783)																				1
Limnephilus lunatus Curtis, 1834					4			1		8		1								
Limnephilus rhombicus (Linnaeus, 1758)									1		1	1								
Goera pilosa (Fabricius, 1775)									2	7	1									
Silo sp.																			8	
Silo pallipes (Fabricius, 1781)	4						20	6	1	1		1			16	5			8	12
Sericostoma personatum (Spence in Kirby & Spence, 1826)	36	20			28		68	24	172	60	140	36	3		24	24	64	32	56	124
Athripsodes sp.								4		68		24	8		12	6	24	32	8	6
Athripsodes bilineatus (Linnaeus, 1758)	26	32			16		56	2	40	12	44	28								
Mystacides sp.										72		3					2			

	Cowleys Heath						Pondhead						Harvestslade		Wootton					
	C 1	C 1	E1	E1	W1	W1	C 1	C 1	US 1	US 1	DS 2	DS 2	H1	NC	P1 S1	P1 S1	P1 S2	P1 S2	P2	P2
	27 Apr 2015	17 May 2016	27 Apr 2015	17 May 2016	27 Apr 2015	17 May 2016	27 Apr 2015	17 May 2016	27 Apr 2015	17 May 2016	27 Apr 2015	17 May 2016	27 Apr 2015	17 May 2016	27 Oct 2015	11 Mar 2016	27 Oct 2015	11 Mar 2016	27 Oct 2015	11 Mar 2016
Mystacides azurea (Linnaeus, 1761)		1							4	32	8	4						2		
Adicella reducta (McLachlan, 1865)							4											1		
Oecetis testacea (Curtis, 1834)									1		4				4					
True Flies																				
Tipulidae		2		1			2				1		1						4	
Limoniidae	2	5			4			1		2	1				4	1	4	2	8	6
Pediciidae	1	19		2			140	44	8	2		60			8	2			5	1
Psychodidae	1																			
Ceratopogonidae	2	1	6	1	4		3	8	44	12	8	12	4		12	1	12	16		1
Simuliidae	38	236	164	200	212	516	512	52			8	160	40	20	24	52	2	20	12	52
Chironomidae	46	276	148	28	224	276	212	52	128	240	164	528	60	124	52	36	56	76	16	80
Tabanidae	3	2	32		1		8	4	64	52	16	8			8	1	4	1	4	
Athericidae													12							
Empididae				1		5						1					8	1		
Ephydridae		1																		

Table 4.3. Species found in the April and October 2015; and March and May 2016 RIVPACS samples with one or more current conservation designations.

Species	Designation	Source
Helophorus (Trichohelophorus) alternans Gené 1836 Water beetle	Nationally scarce – NS Occurring in 16-100 hectads* in Great Britain *10km x 10km squares	Foster, G.N. 2010. A review of the scarce and threatened Coleoptera of Great Britain Part (3) - Water beetles of Great Britain. Species Status 1. Joint Nature Conservation Committee, Peterborough.
Hydrochus angustatus Germar 1824 Water beetle	Nationally scarce – NS Occurring in 16-100 hectads* in Great Britain *10km x 10km squares	Foster, G.N. 2010. A review of the scarce and threatened Coleoptera of Great Britain Part (3) - Water beetles of Great Britain. Species Status 1. Joint Nature Conservation Committee, Peterborough.
Salmo trutta Linnaeus 1758 Brown Trout	England NERC S.41	Species "of principal importance for the purpose of conserving biodiversity" covered under section 41 (England) of the NERC Act (2006) and therefore need to be taken into consideration by a public body when performing any of its functions with a view to conserving biodiversity.
	Biodiversity Action Plan UK list of priority species BAP-2007, Priority Species	The UK List of Priority Species and Habitats contains 1150 species and 65 habitats that have been listed as priorities for conservation action under the UK Biodiversity Action Plan (UK BAP).
Cottus gobio Linnaeus 1758 Bullhead	Habitats Directive Annex 2 - non-priority species	Animal and plant species of Community interest (i.e. endangered, vulnerable, rare or endemic in the European Community) whose conservation requires the designation of special areas of conservation. Note that the contents of this annex have been updated in April 2003 following the Treaty of Accession.

4.3 Other species recorded

As part of the macroinvertebrate sampling protocol, records were also made of the macrophytes recorded within the invertebrate sampling sites. In addition, incidental observations of fish species are also presented (Table 4.4). Whilst neither macrophyte nor fish species were the primary target of the macroinvertebrate sampling, these species are presented as a potentially useful additional baseline against which to assess future change. It is also noteworthy that, despite the small size of these headwater streams, Brown Trout – *Salmo trutta* Linnaeus 1758 appear to have spawned at two of the three Cowleys Heath sites and Bullhead – *Cottus gobio* Linnaeus 1758 were found at several of the sites. Both are also species with conservation designations (Table 4.3).

Table 4.4. Macrophytes (surveyed) and fish species (incidentally observed) in the sampling area of the April and October 2015, and March and May 2016 RIVPACS samples.

End Group	Cowleys Heath						Pondhead						Harvestslade		Wootton					
	C 1	C 1	E1	E1	W1	W1	C 1	C 1	US 1	US 1	DS 2	DS 2	H1	NC	P1 S1	P1 S1	P1 S2	P1 S2	P2	P2
	27 Apr 2015	17 May 2016	27 Apr 2015	17 May 2016	27 Apr 2015	17 May 2016	27 Apr 2015	17 May 2016	27 Apr 2015	17 May 2016	27 Apr 2015	17 May 2016	27 Apr 2015	17 May 2016	27 Oct 2015	11 Mar 2016	27 Oct 2015	11 Mar 2016	27 Oct 2015	11 Mar 2016
Macrophytes																				
Potamogeton sp.			<1%		<1%															
Eleogiton fluitans			<1%																	
Sparganium sp.									<1%											
Oenanthe sp.											<1%						<1%			
Ranunculus flammula													<1%							
Callitriche sp.																				
Amphibians																				
Palmate Newt				1																
Fish																				
Brown Trout (new fry)	2				1															
Bullhead	1	3							5	1	3		1			2		3		
Minnow									1					1		1				
3-Spine Stickleback											1									

4.4 Biotic indices and comparison with reference condition

A subset of the recorded physic-chemical variables was used to build the set of environmental predictor variables (Table 4.5) to run RIVPACS predictions of expected reference condition (un-polluted) biotic indices for the New Forest samples.

RIVPACS predictive models work by assigning test sites to existing RIVPACS model end groups by a weighted averaging approach, based on their physic-chemical predictor variables. These probabilities of end group membership essentially define RIVPACS 'stream types' for the test sites.

Stream types for the New Forest samples are shown in Table 4.6. Most of the New Forest samples were associated with RIVPACS stream types 27, 30 and 40. As is the norm for RIVPACS predictions, most of the New Forest samples were associated with a variety of RIVPACS stream types. End groups with high probabilities of end group membership contribute more information to the prediction of expected biotic indices and those with lower probabilities contribute less.

The probabilities of end group membership provide a useful baseline against which to assess future change as a result of restoration work. For example, the site Cowleys Heath East 1 was 100% associated with RIVPACS end group (stream type) 30. Because end group associations are derived solely by physic-chemical variables, any restoration work that alters those variables, e.g. alters substratum composition, stream width, stream depth, etc., will, therefore, alter the end group associations in future RIVPACS assessments. This in turn will alter the predicted reference condition values of the biotic indices.

This concept, that altering the physicochemical characteristics of the sampling sites through restoration work will also change the end group associations and hence the predicted reference condition biotic indices, is important and leads to two possible future outcomes.

One possibility is that the restoration work may not appreciably alter the end group associations. In this case, the restoration may produce better examples of the same types of stream. A second possibility is that the restoration work will produce physic-chemically different types of stream. In this case, the reference condition predictions of the biotic indices will also shift compared to the presented baseline April 2015 predictions. Presentation here (Table 4.6) of the RIVPACS model end-group associations for the baseline samples will permit future understanding and interpretation of these potential changes.

Following the partial restoration at Cowleys Heath East, and the substantial changes in substratum composition associated with this, there has in fact been no change in RIVPACS end group associations. This means that RIVPACS pre- and post-restoration predictions will be the same. At Cowleys Heath West, in contrast, end group associations have shifted from being spread across end groups 27 and 30, to being almost exclusively associated with end group 27. This means that RIVPACS will now predict a slightly different target community and expected biotic index values for the newly restored channel, given its new physico-chemical characteristics. Harvestslade also has slightly altered end group associations following restoration and it too will have a different target community and expected biotic index values for the new channel versus the original channel.

Table 4.5. RIVPACS environmental predictor variables for the April and October 2015, and March and May 2016, RIVPACS samples (input values for RIVPACS). Origin of variables: [1]measured *in situ* and recorded on RIVPACS sample area form; [2]recorded *in situ* from handheld GPS; [3]derived from 1:50,000 Ordnance Survey map; [4]derived from discharge category map; [5]measured *in situ* with YSI hand-held meter).

Variable	Cowleys Heath						Pondhead						Harvestslade		Wootton					
	C 1	C 1	E1	E1	W1	W1	C 1	C 1	US 1	US 1	DS 2	DS 2	H1	NC	P1 S1	P1 S1	P1 S2	P1 S2	P2	P2
	27 Apr 2015	17 May 2016	27 Apr 2015	17 May 2016	27 Apr 2015	17 May 2016	27 Apr 2015	17 May 2016	27 Apr 2015	17 May 2016	27 Apr 2015	17 May 2016	27 Apr 2015	17 May 2016	27 Oct 2015	11 Mar 2016	27 Oct 2015	11 Mar 2016	27 Oct 2015	11 Mar 2016
Year[1]	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
NGR[2]	SU	SU	SU	SU	SU	SU	SU	SU	SU	SU	SU	SU	SU	SU	SZ	SZ	SU	SU	SZ	SZ
Easting[2]	42392	42392	42006	42006	41418	41418	31990	31987	32392	32392	32446	32446	20697	20675	24995	24995	23347	23347	26383	26383
Northing[2]	02534	02534	02508	02508	02443	02443	06909	06911	06903	06903	06961	06961	05556	05568	99678	99678	00378	00378	98821	98821
Altitude[2]	24	24	20	20	21	21	23	23	23	23	24	24	61	61	27	27	34	34	23	23
Slope[3]	5	5	25	25	11	11	4	4	5	5	5	5	7	7	4	4	4	4	4	4
Discharge category[4]	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Velocity category[1]	2	2	1	1	1	1	2	1	1	1	1	1	2	1	1	1	1	1	2	2
Distance from source[3]	2.3	2.3	0.2	0.2	0.5	0.5	3.5	3.5	2.5	2.5	2.6	2.6	1.1	1.1	5.6	5.6	4	4	7	7
Mean width[1]	2.7	2.8	0.5	0.6	1.2	1.7	2.2	2.7	2.3	2.5	2.8	2.1	0.9	2.2	5	5.2	3	2.5	3.7	3.2
Mean depth[1]	8.3	7.3	8.3	4	14	6.7	6.7	4.7	12.7	16	10	7.3	7	21	10.3	14	37.7	46.3	17.7	23
Boulders and cobbles[1]	0	0	0	5	0	5	0	0	0	0	0	0	5	40	0	0	0	0	0	0
Pebbles and gravel[1]	83	75	40	85	60	92	89	75	85	80	85	75	85	15	85	95	80	90	75	80
Sand[1]	15	20	25	9	20	3	10	23	5	10	10	5	5	0	5	5	10	10	15	18
Silt and clay[1]	2	5	35	1	20	0	1	2	10	10	5	20	5	45	10	0	10	0	10	2
Alkalinity[n/a]	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Hardness[n/a]	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Calcium[n/a]	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Conductivity[5]	234	165	218	123	170	96.9	281	243	273	219	273	219	109	69.6	134	103	112	90.2	118	102

Table 4.6. Stream type (environmental end-group associations) for the April and October 2015, and March and May 2016, RIVPACS samples (output values from RIVPACS; associations <0.01 not shown).

End Group	Cowleys Heath						Pondhead						Harvestslade		Wootton					
	C 1	C 1	E1	E1	W1	W1	C 1	C 1	US 1	US 1	DS 2	DS 2	H1	NC	P1 S1	P1 S1	P1 S2	P1 S2	P2	P2
	27 Apr 2015	17 May 2016	27 Apr 2015	17 May 2016	27 Apr 2015	17 May 2016	27 Apr 2015	17 May 2016	27 Apr 2015	17 May 2016	27 Apr 2015	17 May 2016	27 Apr 2015	17 May 2016	27 Oct 2015	11 Mar 2016	27 Oct 2015	11 Mar 2016	27 Oct 2015	11 Mar 2016
1																				
2																				
3																				
4																				
5																				
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20																				
21																				
22																				
23																				

End Group	Cowleys Heath						Pondhead						Harvestslade		Wootton					
	C 1	C 1	E1	E1	W1	W1	C 1	C 1	US 1	US 1	DS 2	DS 2	H1	NC	P1 S1	P1 S1	P1 S2	P1 S2	P2	P2
	27 Apr 2015	17 May 2016	27 Apr 2015	17 May 2016	27 Apr 2015	17 May 2016	27 Apr 2015	17 May 2016	27 Apr 2015	17 May 2016	27 Apr 2015	17 May 2016	27 Apr 2015	17 May 2016	27 Oct 2015	11 Mar 2016	27 Oct 2015	11 Mar 2016	27 Oct 2015	11 Mar 2016
24							0.01	0.01												
25															0.03	0.12	0.01	0.03	0.01	0.02
26	0.01	0.01					0.01	0.01			0.01				0.02	0.04	0.01	0.02	0.01	0.01
27	0.72	0.7			0.46	0.92	0.57	0.48	0.56	0.49	0.61	0.5	0.97	0.92	0.17	0.28	0.2	0.41	0.05	0.09
28							0.03	0.03				0.01	0.01							
29		0.01																		
30			1	1	0.52	0.08							0.02							
31								0.01												
32																				
33																				
34																				
35							0.04	0.05			0.01	0.01			0.01	0.01				
36																				
37																				
38	0.01	0.01					0.04	0.03	0.01	0.01	0.02	0.01			0.01					
39	0.01	0.01					0.02	0.02	0.04	0.02	0.03	0.04			0.01		0.01		0.01	0.01
40	0.23	0.27			0.01		0.28	0.35	0.38	0.47	0.32	0.43		0.06	0.73	0.53	0.77	0.53	0.91	0.86
41																				
42																				
43																				
Probability of model fit	>5%	<5%	<1%	<0.1%	<1%	<1%	>5%	>5%	>5%	>5%	>5%	>5%	>5%	>5%	>5%	>5%	>5%	>5%	>5%	>5%
Suitability Code	1	2	4	5	4	4	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Note: due to the small size of these New Forest headwater streams, overall RIVPACS model fit was weak (<5%) for some of the Cowleys Heath sites (see 'probability of model fit' in Table 4.6).

Table 4.7 presents the biotic index values for the twenty April and October 2015, and March and May 2016 New Forest samples. Table 4.7 contains 3 panels:

- Observed biotic index values – calculated directly from the macroinvertebrate communities (Table 4.2)
- RIVPACS expected biotic index values – reference condition values of the biotic indices predicted by RIVPACS
- Observed/Expected ratios – observed biotic index values divided by RIVPACS expected biotic index values (O/E ratios)

The biotic indices provide a useful integration of the complex macroinvertebrate species lists in Table 4.3 into simple summary metrics that describe the condition of each of the samples in various different ways. In particular, the observed/expected ratios standardise the observed biotic index values from each site against the expected reference condition values along a common scale around 1, where values less than one indicate that an index has a lower value than expected, and values above one indicate that an index has a higher than expected value. The lower panel of Table 4.7 is colour coded to indicate a 'normal' range of O/E ratios for the biotic indices.

Table 4.7. Observed, Expected (reference condition), and Observed/Expected (O/E) ratios for the RIVPACS samples (RIVPACS input and output values).

	Cowleys Heath						Pondhead						Harvestslade		Wootton					
	C 1	C 1	E1	E1	W1	W1	C 1	C 1	US 1	US 1	DS 2	DS 2	H1	NC	P1 S1	P1 S1	P1 S2	P1 S2	P2	P2
	27 Apr 2015	17 May 2016	27 Apr 2015	17 May 2016	27 Apr 2015	17 May 2016	27 Apr 2015	17 May 2016	27 Apr 2015	17 May 2016	27 Apr 2015	17 May 2016	27 Apr 2015	17 May 2016	27 Oct 2015	11 Mar 2016	27 Oct 2015	11 Mar 2016	27 Oct 2015	11 Mar 2016
OBSERVED biotic index values																				
TL1 BMWP	154	163	112	101	152	62	170	151	166	179	213	204	108	31	187	199	158	167	142	197
TL1 NTAXA	25	26	20	19	24	13	29	26	26	29	33	32	16	7	29	31	26	28	22	33
TL1 ASPT	6.16	6.27	5.60	5.32	6.33	4.77	5.86	5.81	6.39	6.17	6.46	6.38	6.75	4.43	6.45	6.42	6.08	5.96	6.46	5.97
TL2 WHPT Score (AbW,DistFam)	186.8	189.8	141.5	112.2	168.0	63.10	187.6	153.8	179.5	185.3	237.5	234.5	128.3	32.40	214.90	223.00	186.90	192.40	167.5	224.8
TL2 WHPT NTAXA (AbW,DistFam)	29	29	23	22	26	14	31	28	28	31	36	36	18	7	32	33	29	31	24	36
TL2 WHPT ASPT (AbW,DistFam)	6.44	6.55	6.15	5.10	6.46	4.51	6.05	5.49	6.41	5.98	6.60	6.51	7.13	4.63	6.72	6.76	6.45	6.21	6.98	6.24
TL5 AWIC(Sp) Murphy	7.25	7.00	5.50	6.67	6.46	9.00	7.00	7.40	6.91	6.58	6.00	6.50	5.33	4.00	6.56	6.53	6.18	6.00	6.50	6.73
TL5 WFD AWIC(Sp) Mcfarland	10.08	9.80	7.00	9.33	8.55	13.00	9.75	10.00	9.46	9.08	8.40	8.86	6.67	4.00	8.94	8.82	8.64	8.33	8.92	9.40
TL5 LIFE(Sp)	8.30	8.05	7.12	6.64	8.00	8.33	7.92	7.57	7.71	7.55	7.78	7.84	7.89	8.33	8.11	7.96	7.76	7.46	8.11	7.93
TL5 PSI(Sp)	75.56	75.00	30.77	10.53	68.75	50.00	62.71	52.17	60.00	51.56	65.22	58.46	57.14	42.86	78.57	73.91	63.89	56.82	70.59	61.54
TL5 SPEAR(Sp) %	41.00	43.36	36.58	19.60	49.51	15.36	37.04	32.05	48.95	55.86	57.00	47.73	43.66	23.80	35.40	43.46	37.39	36.28	36.74	37.22
TL5 CCI	10.59	15.84	17.50	6.60	9.33	1.00	8.96	8.42	11.54	9.44	11.52	9.31	11.25	1.00	10.20	10.42	10.53	17.08	5.81	10.00
RIVPACS EXPECTED biotic index values																				
TL1 BMWP	147.6	149.0	102.7	102.8	121.4	138.3	147.8	150.1	151.2	154.5	149.7	152.8	141.0	143.50	159.84	163.12	160.12	158.23	165.2	167.1
TL1 NTAXA	23.87	24.08	17.57	17.57	19.94	22.03	24.21	24.68	24.73	25.29	24.39	25.06	22.37	22.848	27.582	26.446	27.672	25.831	28.71	27.77
TL1 ASPT	6.206	6.21	5.835	5.835	6.06	6.278	6.118	6.09	6.136	6.131	6.16	6.119	6.309	6.293	5.772	6.18	5.764	6.148	5.727	6.027
TL2 WHPT Score (AbW,DistFam)	174.3	175.6	127.3	127.3	147.6	166.0	173.4	175.3	176.9	179.9	175.7	178.2	168.9	171.23	183.84	190.33	183.96	184.09	188.4	191.2
TL2 WHPT NTAXA (AbW,DistFam)	26.74	26.97	20.07	20.07	22.57	24.76	27.07	27.58	27.67	28.29	27.30	28.03	25.10	25.636	30.946	29.592	31.091	28.886	32.19	30.99
TL2 WHPT ASPT (AbW,DistFam)	6.546	6.543	6.336	6.336	6.519	6.706	6.429	6.377	6.422	6.392	6.467	6.388	6.734	6.694	5.944	6.449	5.92	6.403	5.84	6.172
TL5 AWIC(Sp) Murphy	6.593	6.599	6.696	6.696	6.601	6.502	6.666	6.702	6.655	6.677	6.635	6.678	6.49	6.51	6.623	6.72	6.605	6.693	6.599	6.816
TL5 WFD AWIC(Sp) Mcfarland	9.116	9.127	9.17	9.17	9.056	8.93	9.244	9.309	9.24	9.282	9.198	9.284	8.915	8.958	9.243	9.328	9.223	9.303	9.232	9.543
TL5 LIFE(Sp)	8.285	8.279	8.411	8.411	8.414	8.43	8.22	8.183	8.192	8.16	8.228	8.166	8.432	8.394	7.767	8.156	7.745	8.151	7.632	7.969
TL5 PSI(Sp)	71.74	71.53	76.93	76.93	76.48	76.50	69.68	68.48	68.65	67.66	69.85	67.79	76.53	75.308	57.46	68	56.755	67.519	53.45	61.69

	Cowleys Heath						Pondhead						Harvestslade		Wootton					
	C 1	C 1	E1	E1	W1	W1	C 1	C 1	US 1	US 1	DS 2	DS 2	H1	NC	P1 S1	P1 S1	P1 S2	P1 S2	P2	P2
	27 Apr 2015	17 May 2016	27 Apr 2015	17 May 2016	27 Apr 2015	17 May 2016	27 Apr 2015	17 May 2016	27 Apr 2015	17 May 2016	27 Apr 2015	17 May 2016	27 Apr 2015	17 May 2016	27 Oct 2015	11 Mar 2016	27 Oct 2015	11 Mar 2016	27 Oct 2015	11 Mar 2016
TL5 SPEAR(Sp) %	56.87	56.84	47.99	48.00	53.48	58.84	54.70	53.87	55.07	54.79	55.69	54.52	59.51	59.084	42.758	54.515	42.822	54.781	41.94	51.59
TL5 CCI	10.84	10.90	15.71	15.71	13.29	11.04	10.83	10.92	10.99	11.10	10.92	11.06	10.70	10.697	11.225	11.231	11.201	11.187	11.63	11.54
OBSERVED/EXPECTED ratios																				
TL1 BMWP	1.04	1.09	1.09	0.98	1.25	0.45	1.15	1.01	1.10	1.16	1.42	1.33	0.77	0.22	1.17	1.22	0.99	1.06	0.86	1.18
TL1 NTAXA	1.05	1.08	1.14	1.08	1.20	0.59	1.20	1.05	1.05	1.15	1.35	1.28	0.72	0.31	1.05	1.17	0.94	1.08	0.77	1.19
TL1 ASPT	0.99	1.01	0.96	0.91	1.05	0.76	0.96	0.95	1.04	1.01	1.05	1.04	1.07	0.70	1.12	1.04	1.05	0.97	1.13	0.99
TL2 WHPT Score (AbW,DistFam)	1.07	1.08	1.11	0.88	1.14	0.38	1.08	0.88	1.01	1.03	1.35	1.32	0.76	0.19	1.17	1.17	1.02	1.05	0.89	1.18
TL2 WHPT NTAXA (AbW,DistFam)	1.08	1.08	1.15	1.10	1.15	0.57	1.15	1.02	1.01	1.10	1.32	1.28	0.72	0.27	1.03	1.12	0.93	1.07	0.75	1.16
TL2 WHPT ASPT (AbW,DistFam)	0.98	1.00	0.97	0.80	0.99	0.67	0.94	0.86	1.00	0.94	1.02	1.02	1.06	0.69	1.13	1.05	1.09	0.97	1.20	1.01
TL5 AWIC(Sp) Murphy	1.10	1.06	0.82	1.00	0.98	1.38	1.05	1.10	1.04	0.99	0.90	0.97	0.82	0.61	0.99	0.97	0.94	0.90	0.98	0.99
TL5 WFD AWIC(Sp) Mcfarland	1.11	1.07	0.76	1.02	0.94	1.46	1.05	1.07	1.02	0.98	0.91	0.95	0.75	0.45	0.97	0.95	0.94	0.90	0.97	0.99
TL5 LIFE(Sp)	1.00	0.97	0.85	0.79	0.95	0.99	0.96	0.92	0.94	0.93	0.95	0.96	0.94	0.99	1.04	0.98	1.00	0.92	1.06	1.00
TL5 PSI(Sp)	1.05	1.05	0.40	0.14	0.90	0.65	0.90	0.76	0.87	0.76	0.93	0.86	0.75	0.57	1.37	1.09	1.13	0.84	1.32	1.00
TL5 SPEAR(Sp) %	0.72	0.76	0.76	0.41	0.93	0.26	0.68	0.59	0.89	1.02	1.02	0.88	0.73	0.40	0.83	0.80	0.87	0.66	0.88	0.72
TL5 CCI	0.98	1.45	1.11	0.42	0.70	0.09	0.83	0.77	1.05	0.85	1.05	0.84	1.05	0.09	0.91	0.93	0.94	1.53	0.50	0.87

observed/expected ratio:	>1.3
	0.7 – 1.3
	0.5 – 0.7
	0.3 – 0.5
	<0.3

4.4.1 Cowleys Heath Sites

The three Cowleys Heath sites had pre-restoration (April 2015) BMWP, NTAXA and ASPT scores that were either close to or exceeded those predicted by RIVPACS (BMWP 1.04 – 1.25; NTAXA 1.05 – 1.20; ASPT 0.96 – 1.05). The same was true for the WHPT indices (Score 1.07 – 1.14; NTAXA 1.08 – 1.15; ASPT 0.97 – 0.99). These indices measure general degradation and (in the case of ASPT) organic pollution stress, of which there appears to be none.

The situation was more complicated with the other biological indices. The two AWIC acidity indices ranged from 0.94 – 1.11 for the C1 Control site and the West 1 site; however there were slightly reduced O/E ratios for the East 1 site (0.76 and 0.82). The PSI index, a measure of sedimentation stress, was also notably reduced at East 1, with an O/E 0.40 compared to 1.05 and 0.90 for the other two sites. The CCI index (a measure of conservation value) was also reduced at East 1 compared to the other two sites.

The Cowleys Heath site East 1 had been subject to recent tree felling work prior to the initial April 2015 survey (see **Appendix II** photograph) and the percentage cover of silt and clay (35%) was the highest of the sites sampled (Table 4.1). It seems likely that sediment release has temporarily affected the stream.

Pre- and post-restoration comparisons at Cowleys Heath East and West are discussed in Section 5.

4.4.2 Pondhead Sites

Pre-restoration (April 2015), the three Pondhead sites had BMWP, NTAXA and ASPT scores that generally exceeded or, in the case of the site Pondhead D/S 2, markedly exceeded those predicted by RIVPACS. (BMWP O/E 1.42, NTAXA O/E 1.35). Similar results were obtained with the WHPT index (WHPT Score O/E 1.35, NTAXA O/E 1.32). All three sites are in good condition with respect to general degradation stress and organic pollution.

Most of the other indices were also close to or exceeded their RIVPACS predictions for the Pondhead sites. The two AWIC acidity indices (O/E values 0.90 – 1.05), the LIFE index (0.94 – 0.96) and the PSI index (0.87 – 0.93) were within normal ranges, indicating no acidity, flow or sedimentation stress. SPEAR and CCI were slightly lower at the Pondhead Control C1 site, but not appreciably so, and all three sites appear to be in overall good biological condition.

The March 2016 follow up re-surveys at Pondhead (where there had been no restoration work carried out) gave broadly similar results, indicating that the Pondhead sites were in good condition and stable.

4.4.3 Harvestslade Site

Pre-restoration, the single Harvestslade old channel site had reduced BMWP and NTAXA scores compared to those predicted by RIVPACS (O/E 0.77 and 0.72) but O/E ASPT was normal at 1.07. Similar results were obtained with the WHPT indices (Score 0.76, NTAXA 0.72 and ASPT 1.06). Most of the other index O/E ratios were within normal ranges, however one of the AWIC indices was quite low (0.75) and O/E PSI was also at the lower end of a normal range (0.75). These scores indicate that the Harvestslade site, whilst not affected by general degradation or organic pollution stress, may have been subject to recent physical disturbance associated with tree felling.

After our April 2015 survey at Harvestslade, the old channel was filled in and a new channel was established. The pre- and post-restoration comparison of the old and new channel is discussed in Section 5.

4.4.4 Wootton Sites

Pre-restoration (October 2015), Wootton Phase 1 Site 1 and Phase 1 Site 2 had generally normal BMWP, NTAXA and ASPT scores compared to those predicted by RIVPACS (O/E ranging between 0.94 and 1.17). The three WHPT indices had similar results (O/E ranging between 0.93 and 1.17). However, the Wootton Phase 2 site had NTAXA values that were a little lower than expected (BMWP and WHPT NTAXA E/O 0.77 and 0.75 respectively). The acidity indices had normal values at all three sites (O/E 0.94 – 0.99), and none of the other indices gave results appreciably lower than those predicted.

The March 2016 follow up re-surveys at Wootton (where there had been no restoration work carried out) gave broadly similar results, indicating that the Wootton sites were in good condition and stable.

5. PRE- AND POST-RESTORATION COMPARISON

Restoration work has been completed at Harvestslade, with initial in-stream works also undertaken at Cowleys Heath. Restoration had not yet taken place at the Pondhead or Wootton sites. A discussion of the pre and post restoration biological condition at Cowleys Heath and Harvestslade is provided below.

5.1 Cowleys Heath Sites

At both the East and West sites of Cowleys Heath, attempts have been made to stabilise the surrounding bogs by raising stream beds using heather bales. Restoration efforts were however restricted due to challenging ground conditions during 2015 and completion of works is now scheduled for 2016.

At Cowleys Heath East, restoration attempts to date have had limited impact on the hydraulic function of the site, with a proportion of the new bed material having been washed away during high flow events. In the post-restoration re-survey (March 2016) Cowleys Heath East had largely unchanged BMWP and WHPT O/E ratios (Table 4.7) following the restoration, indicating that the general degradation and organic pollution status of the channel following restoration was still good. Only 5 percent of invertebrate families had been lost (Figure 5.1**,** A) following restoration.

There is bound to be disruption to the macroinvertebrate fauna following physical disturbance, and this was evidenced by the reduction in PSI O/E (which fell from its already low value of 0.4 to a further low of 0.14), indicating sedimentation stress has occurred. A reduction in CCI O/E from 1.11 to 0.42 was also observed, indicating a reduction in the occurrence of macroinvertebrate species of conservation value.

It is hoped that both of these macroinvertebrate metrics will rise again once the restoration at Cowleys Heath East has had time to stabilise, sediment has had a chance to clear, and species of greater conservation value have had time to re-colonise from adjacent watercourses. Further monitoring is recommended to assess both the time needed for recovery of the macroinvertebrate community to its former condition, and to assess whether the future community of the newly restored channel can in time exceed that found before the restoration was carried out.

At Cowleys Heath West, the efficacy of raising the bed level with heather bales has also been limited, with much of the material having been washed away. The addition of new gravel was, however, evident and the substratum has as a result become coarser, with less sand, silt and clay. In the post-restoration re-survey (March 2016), Cowleys Heath West had notably reduced BMWP and WHPT O/E ratios (Table 4.7) following the restoration, indicating that river had become degraded. This is also reflected in a marked 46 percent reduction in invertebrate families between pre- and post-restoration assessments (Figure 5.1**,** B). The invertebrate fauna at Cowleys Heath West has, therefore, been substantially reduced. Further evidence of disruption is seen in the O/E CCI score, which fell from 0.7 to 0.09, indicating a near complete removal of macroinvertebrate species of conservation value as a result of the restoration.

As with Cowleys Heath East, it must be borne in mind that the re-survey closely following a river restoration is going to show impacts on the macroinvertebrate community, especially where the streambed itself has been extensively modified by large scale gravel addition. Again, we strongly recommend further surveys to monitor recovery of the macroinvertebrate community to its former condition, and to assess whether the future community of the newly restored channel can, in time, exceed that found before the restoration was carried out.

5.2 Harvestslade Site

At Harvestslade, the original river channel had been filled-in and a the old meander reactivated. The new channel had a substratum with a high percentage of clay, and notably brown discolouration to the water.

In the post restoration survey of the new channel on 11th March 2016, the biological quality of the new channel was found to be extremely low. Almost all of the observed/expected macroinvertebrate indices in the new channel were low or very low. The BMWP and WHPT indices (especially Score and NTAXA) were very low indeed at 0.22 and 0.31 respectively. WHPT Score and NTAXA were similarly reduced (0.19 and 0.27 respectively). This is reflected in a 56 percent reduction in invertebrate families between pre- and post-restoration assessments (Figure 5.1, C). The O/E for the CCI index was also very low indeed at 0.09, indicating that no macroinvertebrate species of conservation value were present.

Constructing what is effectively a new river channel is perhaps the most substantial form of river restoration that can be undertaken and, as such, it is not surprising that a biological survey that is conducted shortly afterwards will find a very poor community present. The new channel is clearly in the very earliest stages of stabilisation and re-colonisation and we strongly recommend further monitoring to assess the gradual recovery of the channel to see whether it can, in time, reach and exceed the biological condition and conservation value of the original channel.

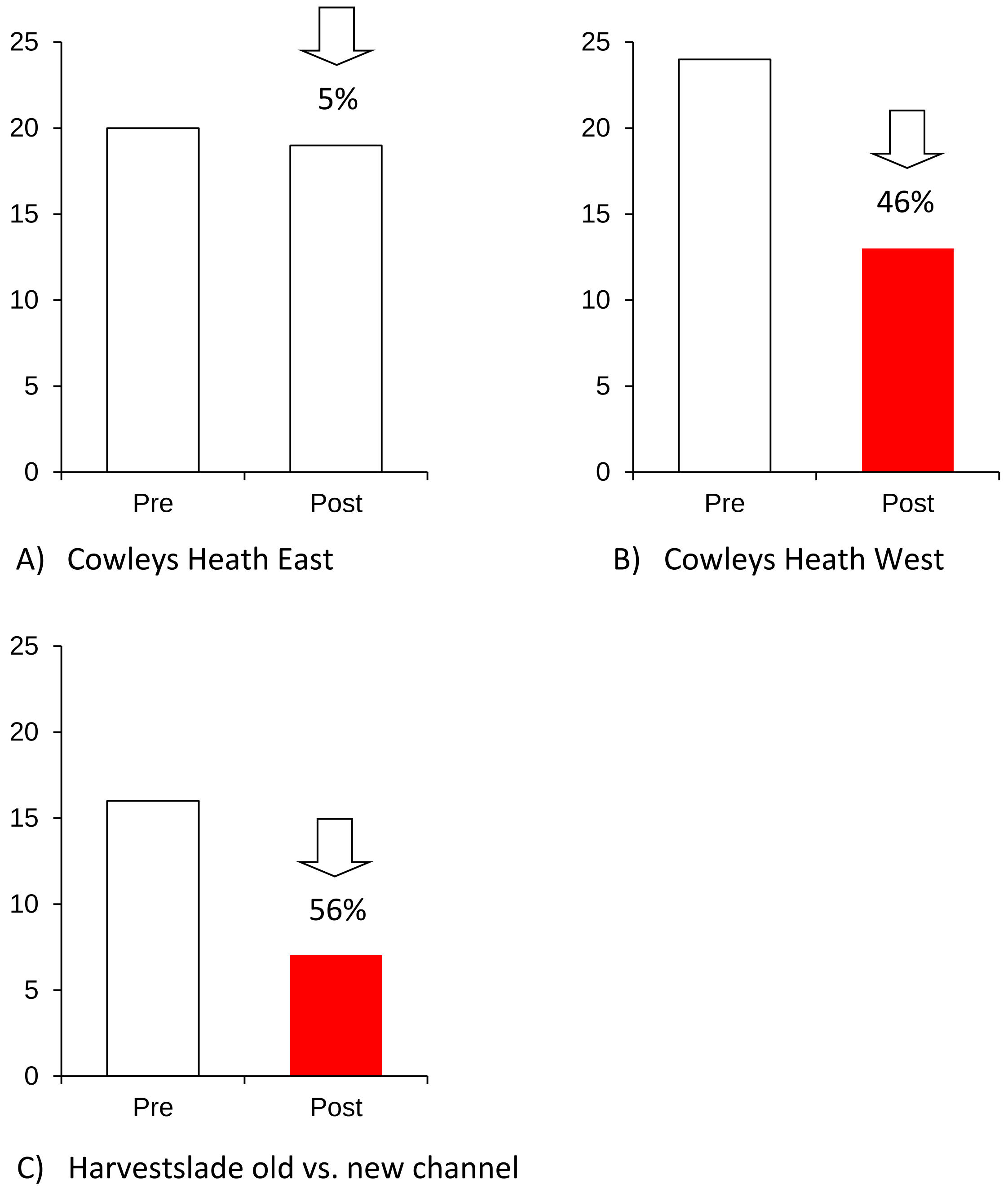

Figure 5.1. Comparison of pre and post restoration changes in the number of invertebrate families (NTAXA) at A) Cowleys Heath East; B) and Cowleys Heath West; and C) Harvestslade old channel vs. new channel. Pre and Post samples taken 27 April 2015 and 17 May 2016 respectively.

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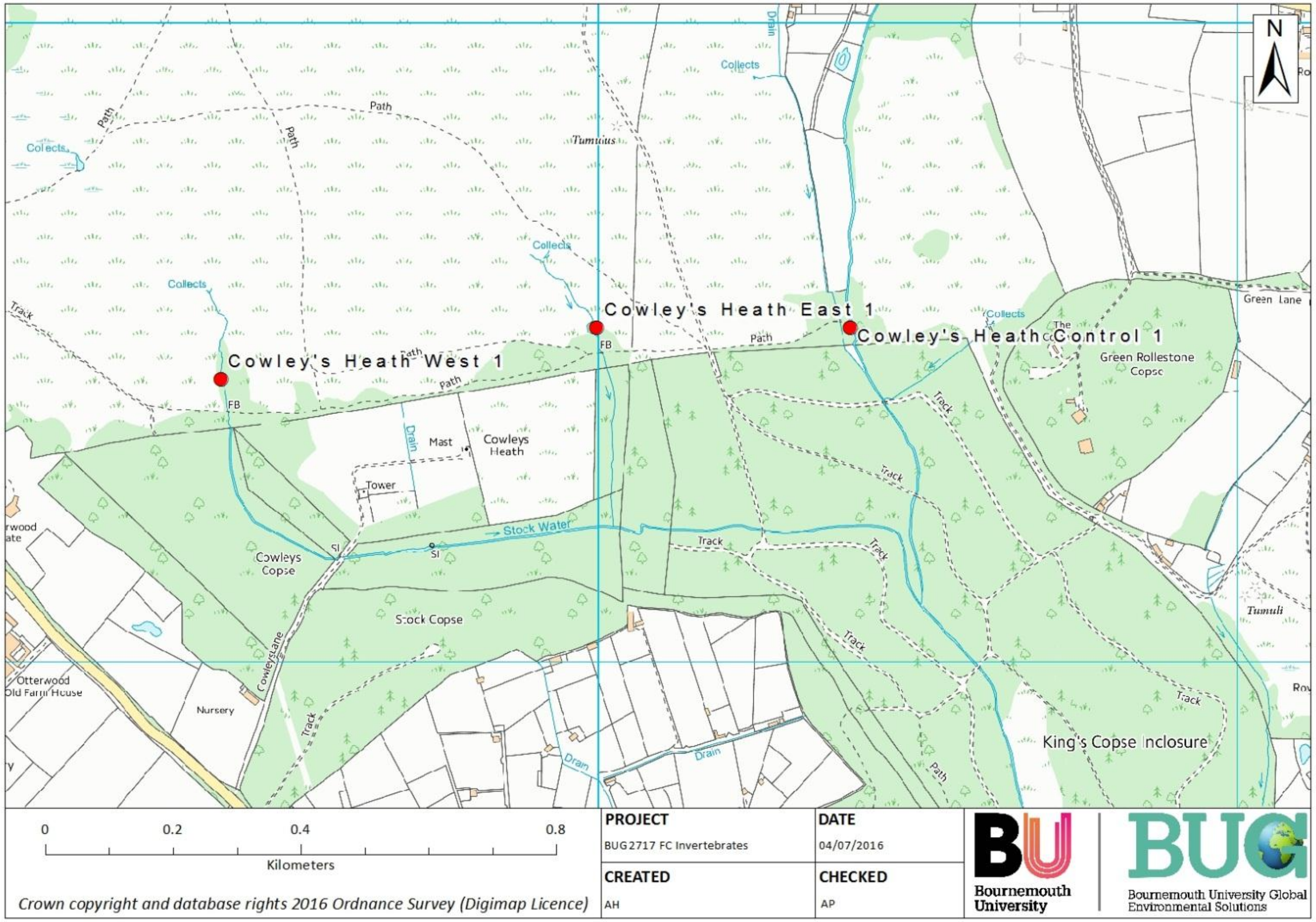
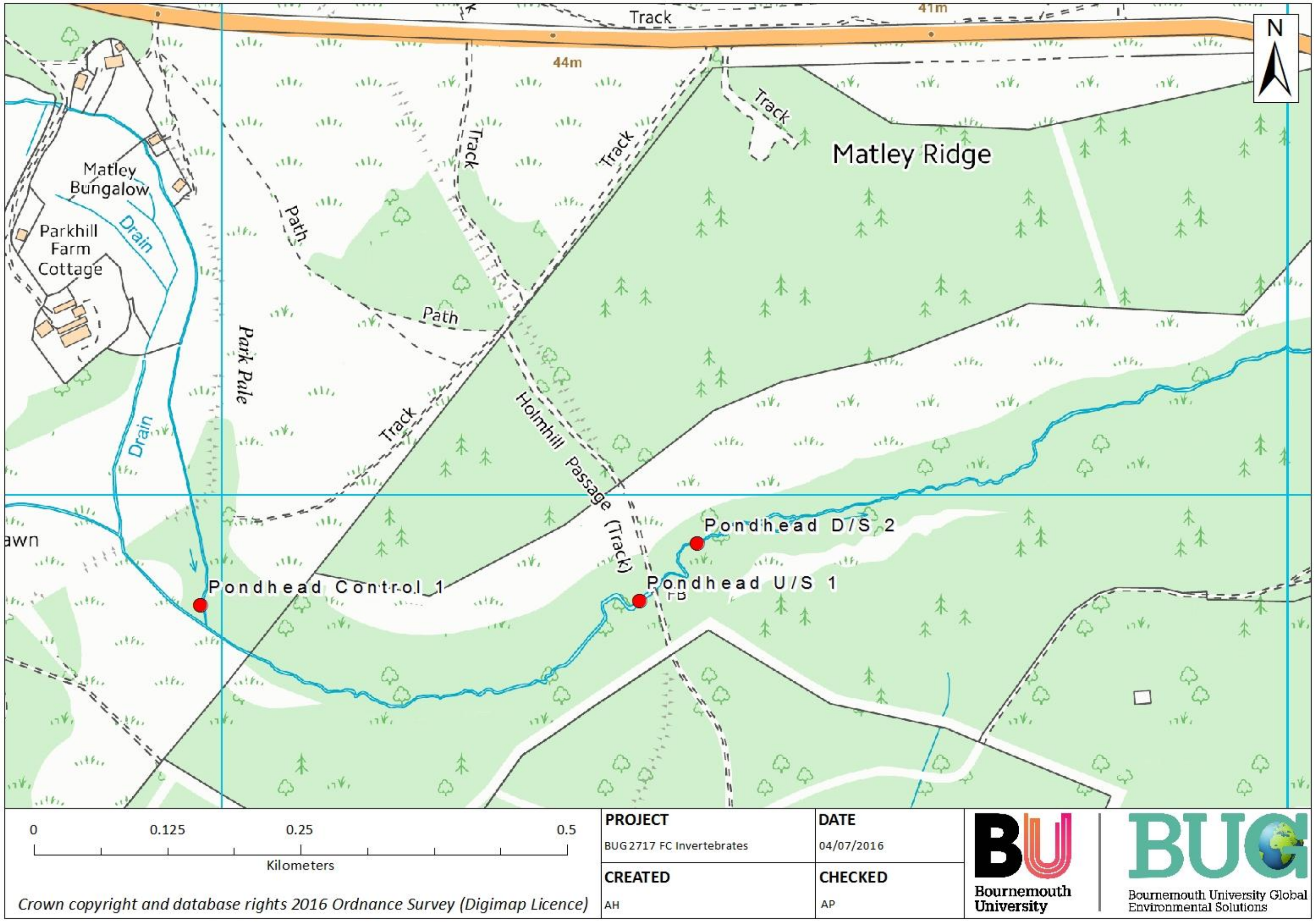
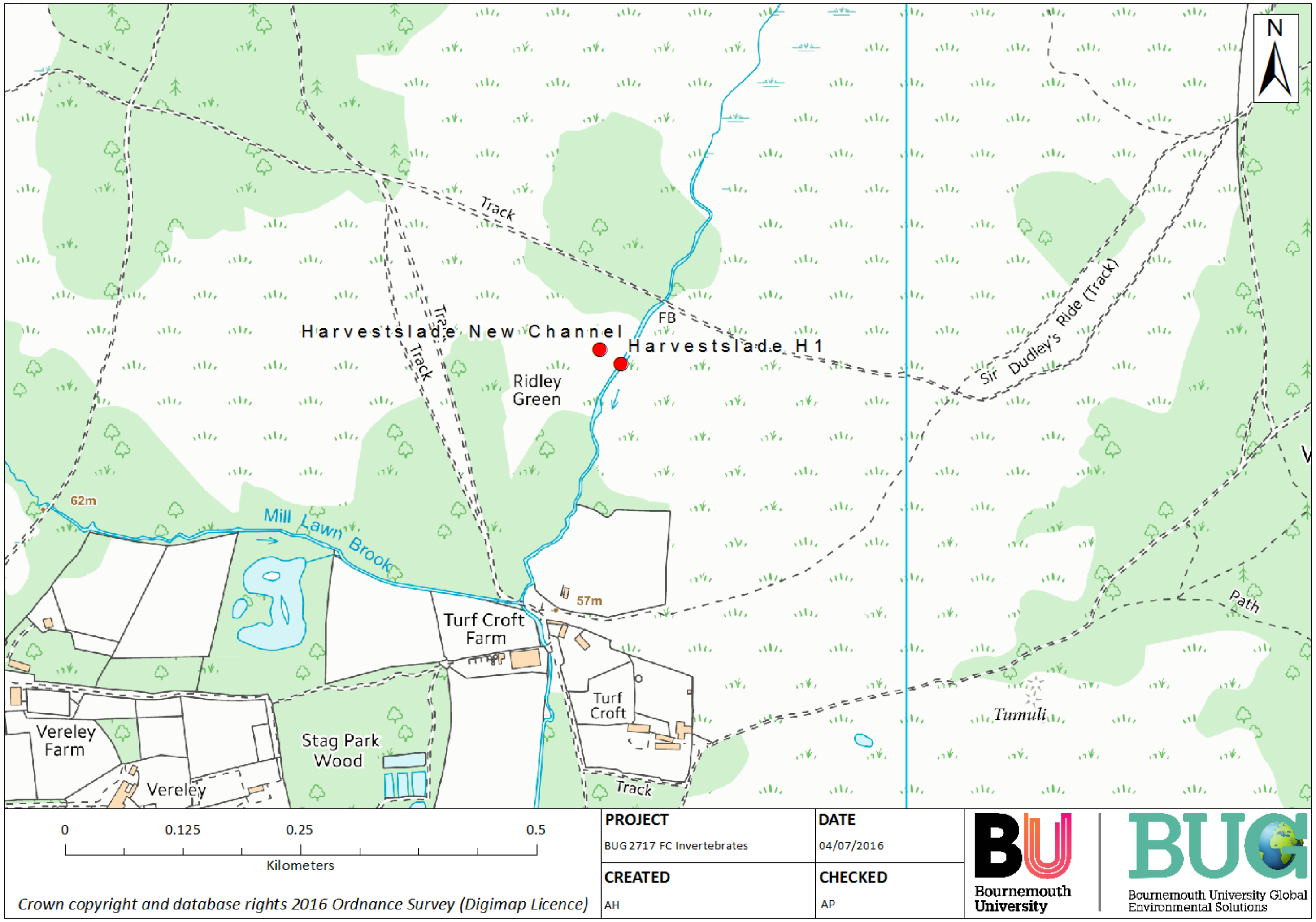


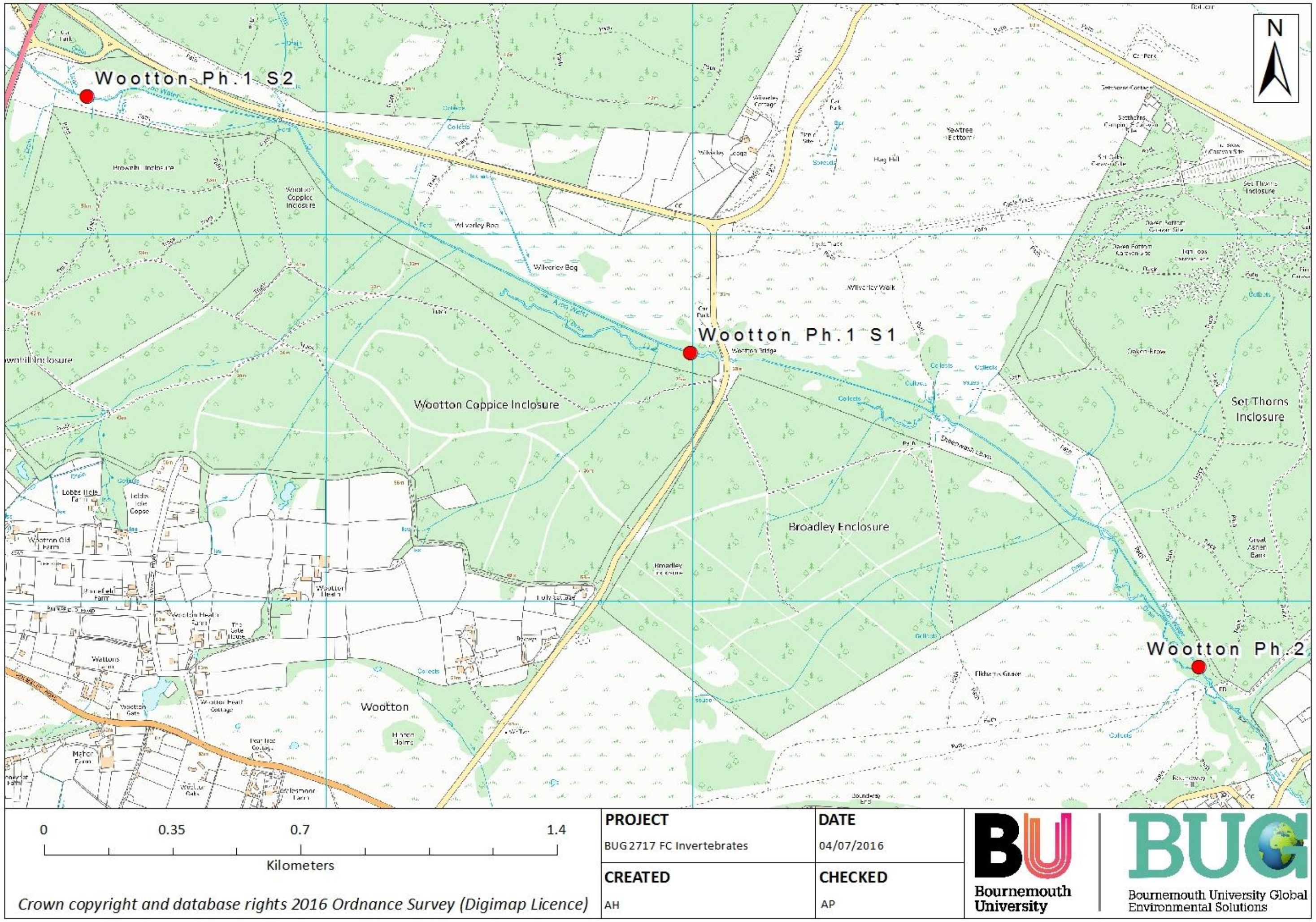
Cowley's Heath – Sampling Sites



Pondhead – Sampling Sites



Harvestslade – Sampling Sites



Wootton – Sampling Sites

Cowleys Heath Control (C1), April 2015

Cowleys Heath Control (C1), May 2016

Cowleys Heath East 1, April 2015 (Pre-works)

Cowleys Heath East 1, May 2016 (Post-works)

Cowleys Heath West 1, April 2015 (Pre-works)

Cowleys Heath West 1, May 2016 (Post-works)

Pondhead Control (C1), April 2015

Pondhead Control (C1), May 2016

Pondhead U/S 1, April 2015 (Pre-works) **Pondhead U/S 1, May 2016 (No work undertaken)**

Pondhead D/S 2, April 2015 (Pre-works)

Pondhead D/S 2, May 2016 (No work undertaken)

Harvestslade 1, April 2015 (Old channel)

Harvestslade 1, May 2016 (Old channel filled in)

Harvestslade 1, May 2016 (New channel)

Wootton Phase 1, Site 1 October 2015 (No work undertaken)

Wootton Phase 1, Site 1 March 2016 (No work undertaken)

Wootton Phase 1, Site 2 October 2015 (No work undertaken)

Wootton Phase 1, Site 2 March 2016 (No work undertaken)

Wootton Phase 2, October 2015 (No work undertaken)

Wootton Phase 2, March 2016 (No work undertaken)

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