River Lavant Condition Assessment and Walkover Survey Report

April – May 2024

Prepared for: The South Downs National Park Authority

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Amidst the South Saxonian hills there runs
A verdant fruitful value in which, at once
Four small and pretty villages are seen;
Eastden, the one, does first supply the spring
Whence silky Lavant takes his future course;
Carlton next, the beauty of the four.
From twenty chalky rills, fresh vigour adds;
Then swiftly on, his force redoubled, he
Through all the meadows, to Singlton does glide;
More strength he there receives, then boldly runs.
Till less confin'd he wider spreads his fame,
And passing Lavant, there he takes his name.

Anonymous poem c. 1737
Taken from Newbury (2000)

Executive Summary

The South Downs National Park Authority (SDNPA) commissioned a River Condition Assessment and walkover survey of the upper Lavant between East Dean and East Lavant. The purpose of the survey was to build a greater understanding of the physical characteristics and naturalness of the river corridor and identify the factors that are currently exerting a negative impact on the river system and its resilience to pressures from wastewater pollution.

The Lavant is one of three designated chalk streams in Sussex that rise from the chalk aquifers in the South Downs National Park. In their natural state, these internationally rare habitats have clear mineral rich water with low nutrient levels and stable temperatures and support abundant and diverse array of flora and fauna. The River Lavant is classified as a winterbourne that rises from chalk springs at East Dean and flows for approximately 13km before entering Chichester Harbour, an internationally designated site for conservation. Since 2010, the Lavant has consistently been classified as having 'poor' ecological status with the most recent assessment (2022) indicating that fish, along with macrophyte and phytobenthos elements are poor whilst phosphate and invertebrate elements are classified as moderate, with pollution from wastewater cited as the main cause. Previous assessments by the Environment Agency indicate invertebrate and fish communities were less numerous and diverse on the Lavant compared to other Sussex chalk waterbodies likely due to a combination of public water supply abstractions, sewage treatment works discharge, and in channel obstructions.

This report details the combined results of a River Condition Assessment (RCA) and Walkover Survey which have been analysed to evaluate the physical habitat and geomorphological condition, along with the extent of modification and other characteristics of the River Lavant from its source at East Dean to East Lavant.

The surveys found that there are some nice examples of chalk stream habitat along the upper Lavant with six (30%) subreaches being classified as "Fairly Good" and supporting high morphological and habitat diversity. Several sites located between Singleton and Binderton also supported good marginal habitat and diverse macrophyte communities with notable beds of *Ranunculus peltatus* which is a key winterbourne species of high conservation value.

There were, however, several elements considered to be limiting the ecological health of the river. These included point and diffuse sources of pollutants, management or neglect of riparian margins, modifications, a lack of physical features, and invasive non-native species. Observed discharge of sewage into the river system will be having a major impact on its overall health, and it is recommended that restoration of the Lavant is underpinned by ongoing and constructive dialogue with Southern Water over future plans and timeframes under which progress to reduce sewage pollution will progress.

The survey has identified considerable scope to increase the condition, and overall resilience, of the Lavant by reducing the impact of human interventions and increasing the morphological and habitat diversity through riparian and in-channel enhancements. By delivering such enhancements, it is predicted that there is potential to achieve 'fairly good' condition or above across 13 (65%) of subreaches. These opportunities are summarised within this report with additional information provided in a series of site descriptions as an appendix (A) to the main document.

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1. Introduction

1.1. Background

The South Downs National Park Authority (SDNPA) have acquired funding from Portsmouth Water and The South Downs Trust to carry out investigations into the ecological condition of the River Lavant so that an effective and sustainable approach to improving its health and resilience can be developed. To help direct this work, the Authority have commissioned a River Condition Assessment and walkover survey of the upper Lavant between East Dean and East Lavant. The purpose of the survey is to build a greater understanding of the physical characteristics and naturalness of the river corridor and identify the factors that are currently exerting a negative impact on the river system and its resilience to pressures from wastewater pollution.

The survey was carried out between April and May 2024 with the aim of assessing the current condition of the River Lavant and making recommendations for future enhancements works.

1.2. Ecological background

The Lavant is one of three designated chalk streams in Sussex that rise from the chalk aquifers in the South Downs National Park. In their natural state, these internationally rare habitats have clear mineral rich water with low nutrient levels and stable temperatures, and support abundant and diverse array of flora and fauna. Deriving most of their flow from groundwater, chalk streams are influenced by temporal patterns in their groundwater source and can be grouped into three broad types. These include intermittent types that are dry for the majority of the year but are periodically inundated when groundwater is at its highest; winterbournes that have a naturally dry period each year and experience a gradual shift from winter wet, low phases and summer dry phase; and perennials that permanently flow due to reliable groundwater inputs. Most chalk streams will include more than one type as they flow from source to sea and these longitudinal shifts in flow permanence result in varied habitats that support high biodiversity.

The River Lavant is classified as a winterbourne that rises from chalk springs at East Dean and flows for approximately 13km before entering Chichester Harbour which is an internationally designated site for conservation. It drains a predominantly permeable chalk catchment of 91.2km^2 which limits surface runoff and is principally groundwater-fed. A discharge gauging station is situated at Graylingwell, just north of Chichester which shows that the river is generally dry here from July through to November/December. In addition, observations and ecological data collected by the Environment Agency in 2002 and 2004 suggest that flow is intermittent at the source and can often persist longer upstream of Graylingwell, between West Dean and Binderton (Environment Agency, 2002,2004, Newberry, 2000). Flow permanency is primarily influenced by groundwater levels, however, there are two significant groundwater abstractions from wells at Brick Kiln and Lavant which reduce river flows (Moore & Bell 2002) and a sewage treatment works located further downstream at Lavant that augments flow from discharge (Environment Agency 2004).

Regulatory monitoring to assess Water Framework Directive (WFD) status is undertaken by the Environment Agency at East Lavant and Apuldram (Figure 1). Since 2010, the Lavant has consistently been classified as having 'poor' ecological status. The most recent cycle (2019-2022) indicates that fish, and macrophyte and phytobenthos quality elements are poor and phosphate and invertebrate elements are moderate, with pollution from wastewater cited as the main cause (Environment Agency, 2022). Furthermore, ecological data collected by the Environment Agency between 1999 and 2004 show that invertebrate and fish communities were less numerous and diverse on the Lavant compared to other Sussex chalk waterbodies and that the depauperate ecology was likely due to a combination of public water supply abstractions, sewage treatment works discharge, and in channel obstructions (Environment Agency 2004).

In the last few years, major concerns have been raised about the amount of sewage entering the River Lavant from storm overflows and pumping from surcharged pipes due to high levels of groundwater overloading the sewer system. According to residents at East Dean, over-pumping has been undertaken for over a decade and in 2023 the storm overflow at Lavant spilled 286 times for a total of 6,542 hours. This places the river at risk of eutrophication (elevated nutrient enrichment) that can directly impact plant populations and have secondary effects on other organisms including fish and invertebrates. It can also be exacerbated where flow is impeded by natural (climatic) or unnatural (modifications, abstraction) factors and where physical morphology is poor. Furthermore, the Lavant flows into Chichester Harbour, a site of considerable importance for biodiversity and recreation which is currently in unfavourable declining condition due to reasons that include water quality.

1.3. Scope of this report

This report details the following:

- The results of the river walkover survey comprising Habitat Modification Scores, distribution of invasive non-native plants, macrophyte observations and other impacts identified during the survey.
- The results of a River Condition Assessment (RCA) field survey and desk study comprising a classification of current condition and an assessment of 32 condition indicators.
- A summary of the main enhancement and priority actions based on the survey results.
- A forecast of river condition based on the suite of enhancements to the purpose of delivering Biodiversity Net Gain.

Detailed descriptions and recommendations for each site that was subject to a survey are provided in Appendix A.

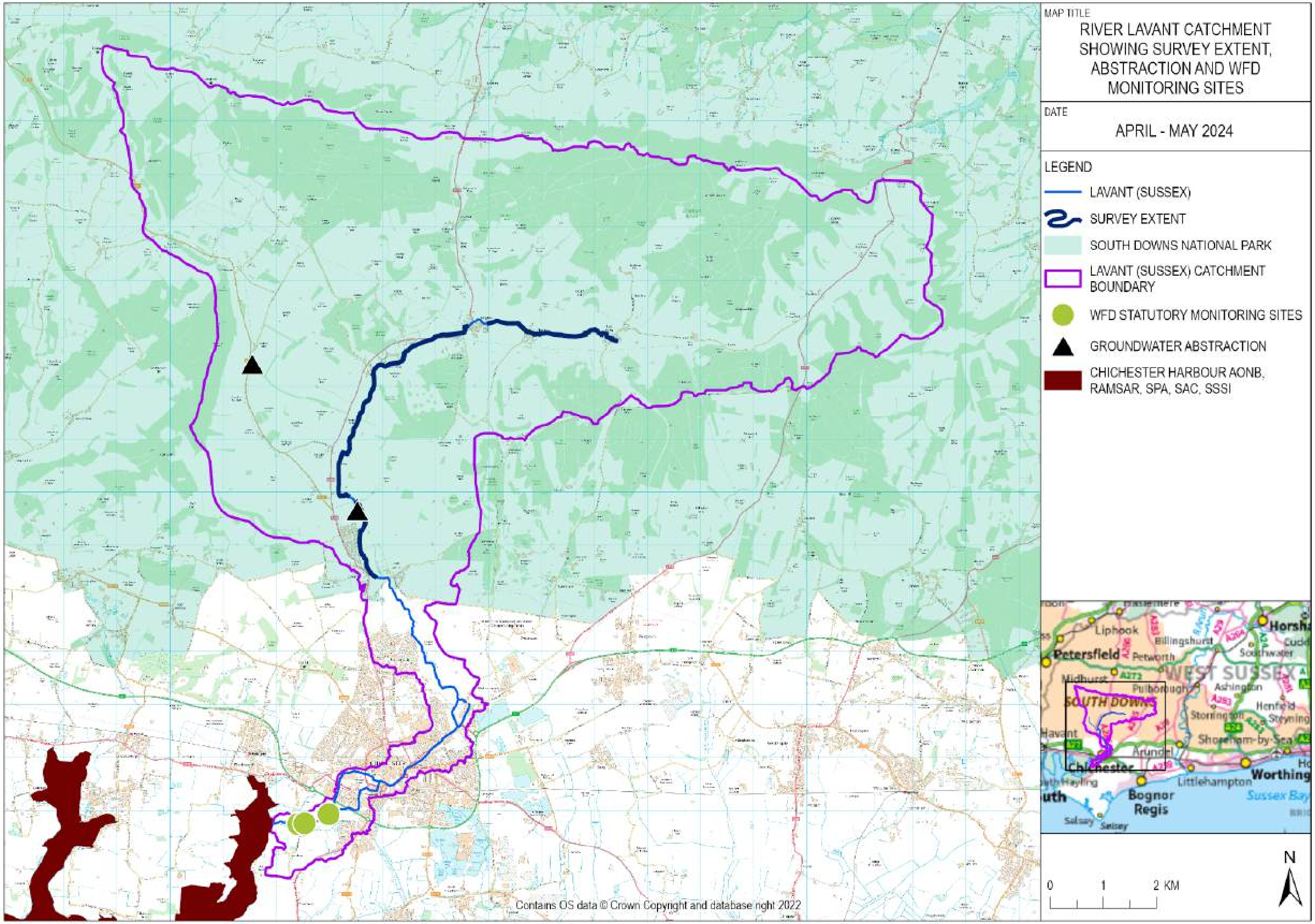

Figure 1: Map showing Lavant catchment, survey extent, abstraction (Taken from Moore & Bell, 2002), WFD monitoring locations (© Environment Agency copyright and/or database right 2016. All rights reserved)and boundaries of the South Downs National Park and Chichester Harbour designated site for nature conservation (© Natural England)

2. Survey Methodology

2.1. River Condition Assessment

A River Condition Assessment (RCA) was used to evaluate the physical habitat and geomorphological condition of the River Lavant from its source at East Dean to East Lavant. This approach uses the field- and desk-based components of the Modular River Physical (MoRPH) Survey which are summarised below:

2.1.1. MoRPH5 Field Survey

The MoRPH5 field survey characterises short sections of river (referred to herein as subreaches) based on the morphology, sediments, physical features, and vegetation structure of the river channel and margins within 10m of the bank top. Each subreach comprises 5 contiguous survey modules which vary between 10, 20, and 50m lengths depending on the river width and within which the type and abundance of all physical features are recorded and include:

- Terrestrial (riparian) and aquatic vegetation
- Tree features (e.g. large woody debris, fallen trees)
- Water related features (pond, wetlands)
- Natural and artificial bank and channel profiles and materials
- Natural physical bed and marginal features (e.g. bars, riffles, pools)
- Surface water flow types
- Artificial features (e.g. weirs, culverts, outfalls)
- Non-native (invasive) species

This information is used to assign a provisional numerical condition score for each subreach based on 32 condition indicators (19 positive and 13 negative). These characterise the condition of different aspects of bank tops (<10m of river), bank faces, channel edge – water margin, and channel bed, and can be used to direct enhancement works.

2.1.2. MoRPH Desk Study: Indicative River Typing

The desk-based study determines the (indicative hydromorphological) River Type for an extended river reach. A reach is defined by a stretch of river that has similar planform, sediment and flow regimes and will contain one or more of the surveyed subreach(es). The River Type is calculated based on measures of planform (e.g. single or multi-thread rivers, level of sinuosity), valley confinement and gradient derived from GIS or google earth and uses data on the bed materials collected from the field survey.

A total of 15 indicative river types have been classified for England and include 13 river planform-bed material types, canals/navigable rivers, and large rivers (>30m wide). Each river type has an expected range of positive condition indicator scores that represent what the river may display when it is naturally functioning.

2.1.3. Final River Condition Scores

A final condition score is calculated for each subreach by comparing the provisional condition indicator scores within the expected scores for that river type. The final scores are then translated into one of five categorical conditions (5-good, 4-fairly good, 3-moderate, 2-fairly poor, 1-poor). If the river is considered over deep (partly or wholly disconnected from the riparian margin/floodplain), the final condition score is reduced by one category (e.g. moderate to fairly poor). This is calculated based on the width to height ratio (river shape: <2 highly confident, <4 moderately confident) and expert judgement.

2.2. River Walkover Survey

Walkover surveys were undertaken along extended lengths of river, referred to herein as river sections, and included one or more of the MoRPH5 subreaches. The walkovers survey collected information on the following:

- Extent of bank side trees and evidence of disease
- Land us along the river corridor
- Wetland features present in the floodplain
- Presence of macrophytes or other notable species
- Location and extent of river modifications (e.g. weirs, reinforcements, re-sectioning)
- Location and extent of non-native (invasive) species
- Locations of any sediment or pollution pathways

All data was collected in the Survey123 field app and mapped using ArcGIS Pro 3.

2.2.1. Habitat Modification Score

Modifications recorded from the Walkover Survey were used to derive Habitat Modification Scores following the River Habitat Survey 2018 revised scoring system. Final scores were translated into five modification classes (pristine/semi-natural: 0-16, predominantly unmodified: 17-99, obviously modified: 200-499, significantly modified: 500-1399, severely modified: >1400).

2.2.2. Survey Area

The survey area included 17 sections of the River Lavant between its source at East Dean (Ordnance Survey Grid Reference SU 90796 12959) and East Lavant (Ordnance Survey Grid Reference SU 85710 08602). Sections were approximately 500m in length and aligned with landowner boundaries, land cover, and/or features such as roads. All sections were subject to a River Walkover Survey and 16 sections were subject to one or more MoRPH5 surveys. A table showing the relationship between the MoRPH5 subreaches and River Walkover Survey sections is provided in Table 1 and a map showing the distribution of each section and subreach survey module is provided in Figure 2.

All results are described with reference to the left and right bank which is the physical left and right sides of the channel when facing in a downstream direction.

Table 1; showing the relationship between River Walkover Survey Sections and MoRPH5 survey subreaches that were assessed along the River Lavant in April and May 2024.

River Walkover Survey			MoRPH5 Survey			
Section ID	**Central OSGR**	**Length (m)**	**Subreach**	**Central OSGR**	**Module length**	**MoRPH5 length (m)**
RL01	SU 9030712898	177	Not surveyed			
RL02	SU 89969 13055	773	RL02a	SU 90023 13053	10	50
			RL02b	SU 89730 12947	10	50
RL03	SU 89235 12980	563	RL03	SU 89462 12957	10	50
RL04	SU 88857 12991	264	RL04	SU 88851 12997	10	50
RL05	SU 88411 13176	768	RL05	SU 88513 13187	10	50
RL06	SU 87462 13007	453	RL06	SU 87412 12997	10	50
RL07	SU 87132 12964	242	RL07	SU 87180 12967	20	100
RL08	SU 86822 12849	361	RL08	SU 86829 12840	10	50
RL09	SU 86422 12585	668	RL09	SU 86439 12640	10	50
RL10	SU 85960 12414	485	RL10a	SU 86063 12368	10	50
			RL10b	SU 85879 12342	20	100
RL11	SU 85853 12072	279	RL11	SU 85841 11985	20	100
RL12	SU 85644 11599	416	RL12	SU 85653 11656	20	100
RL13	SU 85387 10926	459	RL13a	SU 85544 11338	10	50
			RL13b	SU 85403 11029	10	50
RL14	SU 85181 10542	570	RL14a	SU 85252 10707	10	50
			RL14b	SU 85180 10519	10	50
RL15	SU 85179 10037	539	RL15	SU 85177 10100	20	100
RL17	SU 85572 09741	313	RL17	SU 85574 09745	10	50
RL18	SU 85568 09072	1000	RL18	SU 85634 09287	10	50

2.3. Survey Personnel and Timings

The River Condition Assessments were undertaken by Dr. Rowenna Baker and the River Walkover Surveys were undertaken by Sandra Manning-Jones. Rowenna is an accredited RCA surveyor with over 10 years' experience of surveying rivers of various river types including chalk streams across the Southeast region. Sandra Manning Jones is an experienced river surveyor and has worked on development of a chalk stream strategy for the River Ems and has undertaken planning and delivery of floodplain and river restoration projects in Sussex.

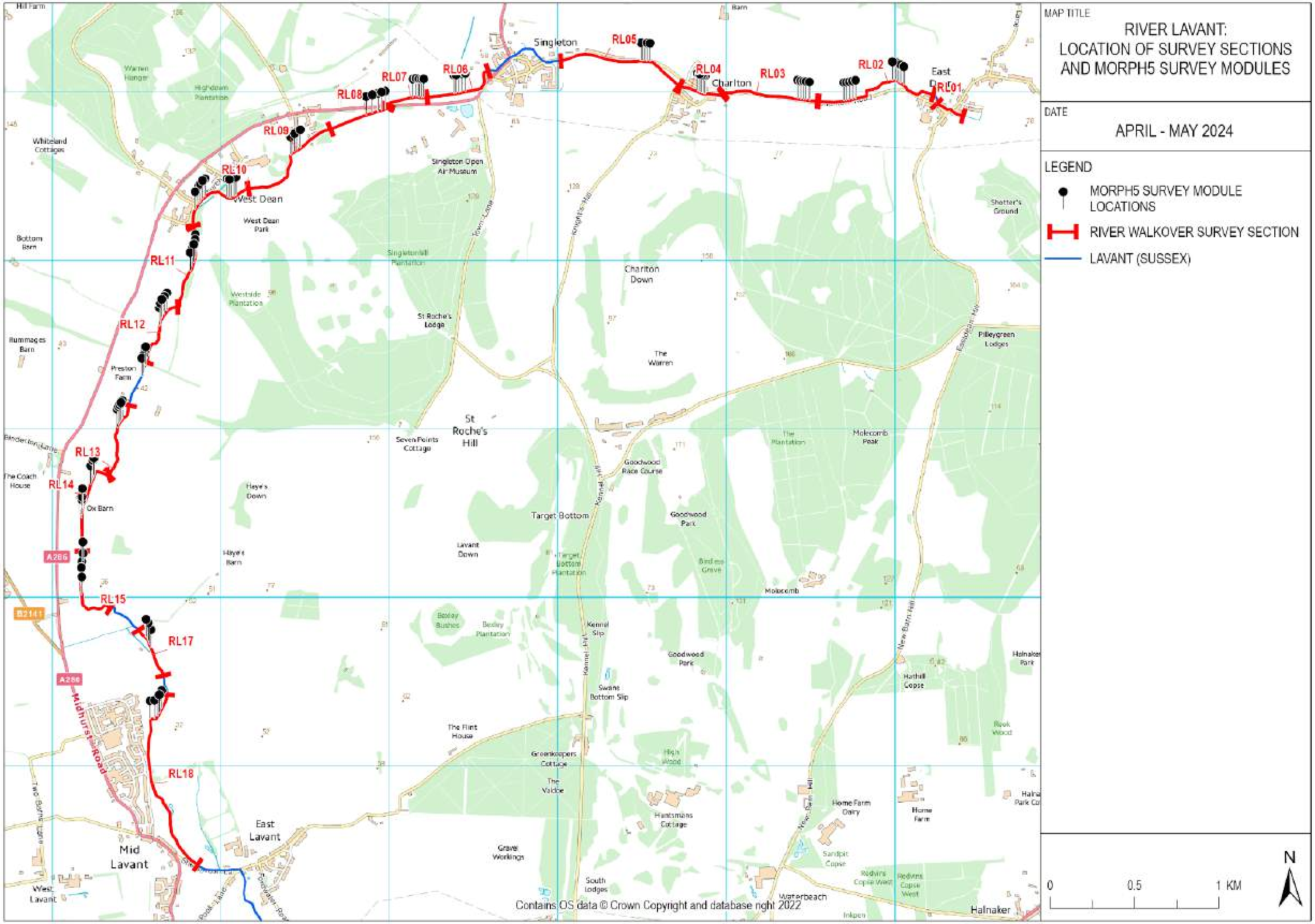

Figure 2: Map showing location of river sections subject to a river walkover survey and location of survey modules subject to a MoRPH5 River Condition Assessment

3. Results

3.1. Reach characteristics

The River Lavant was separated into three extended reaches based on changes in planform and/or presence of macrophytes that suggested changes in river flow (refer to 3.8). Reach 1 was located between the source of the Lavant at East Dean and Charlton with an average river width of 1m. This reach was dominated by non-aquatic grasses and herbs with flows rarely extending beyond April (personal communications). Reach 2 is located between Charlton and Centurion Way where the river is generally wider (average 3.7m) and contains a mixture of aquatic annuals and terrestrial grasses and herbs. Several springs located at Charlton and Singleton, and the Southern Water pumping station at Singleton, add vigour to the river through this reach with species indicative of faster flowing reaches (e.g.*Lemanea spp*) starting to appear. Reach 3 is located between Centurion Way and East Lavant. The river through this reach flows through a wide floodplain and is dominated by fast-growing aquatic annuals. Photos showing examples of each reach are provided in Plates 1-3.

Plate 1: Photos showing general character of Reach 1 where left is subreach RL01, middle is subreach RL02 and right is subreach RL03.

Plate 2: Photos showing general character of Reach 2 where left is subreach RL04, middle is subreach RL06 and right is subreach RL09.

Plate 3: Photos showing general character of Reach 3 where left is subreach RL12, middle is subreach RL13b and right is subreach RL18

3.2. MoRPH5 Indicative River Type

Each of the three survey reaches were classified as River Type F, single thread, unconfined, low gradient straight-sinuous river of relatively course bed material comprising gravel pebble and localised areas of courser cobbles and chalk bed rock in the lower reaches (Table 2). The average river width ranged from 0.6 to 5.4m and generally increased from upstream to downstream (Figure 3).

Table 2: characteristics of each subreach based on the MoRPH 5 field survey and river type assessment. River type calculated using bed materials shown in bold where CO is cobble, SI(EA) is earth, GP is gravel-pebble, BE is bedrock (chalk)

Reach	Sub-reach	Length (km)	Sinuosity	Planform	Confinement	Valley gradient (m.m-1)	Coarsest bed material	Av. alluvial bed material size class	River type	Av. river width (m)	River Shape
1	RL02a RL02b RL03	1.72	1.061	Straight-sinuous	Unconfined	0.008	GP GP GP	SI GP GP	F	1.20 0.60 1.12	2.857 0.588 0.982
2	RL04 RL05 RL06 RL07 RL08 RL09 RL10a RL10b RL11	4.29	1.064	Straight-sinuous	Unconfined	0.005	CO GP GP CO GP CO CO GP GP	GP GP GP GP GP GP GP GP GP	F	2.10 1.50 3.00 4.70 4.30 4.30 3.80 5.40 4.40	1.667 1.415 4.839 6.184 5.513 2.986 3.725 5.934 4.00
3	RL12 RL13a RL13b RL14a RL14b RL15 RL16 RL18	3.47	1.045	Straight-sinuous	Unconfined	0.004	GP GP GP CO GP CO BE GP	GP GP GP GP GP GP GP GP	F	5.10 3.50 4.30 3.38 3.54 4.70 4.50 4.40	5.930 5.645 6.232 4.630 5.057 6.714 5.556 2.857

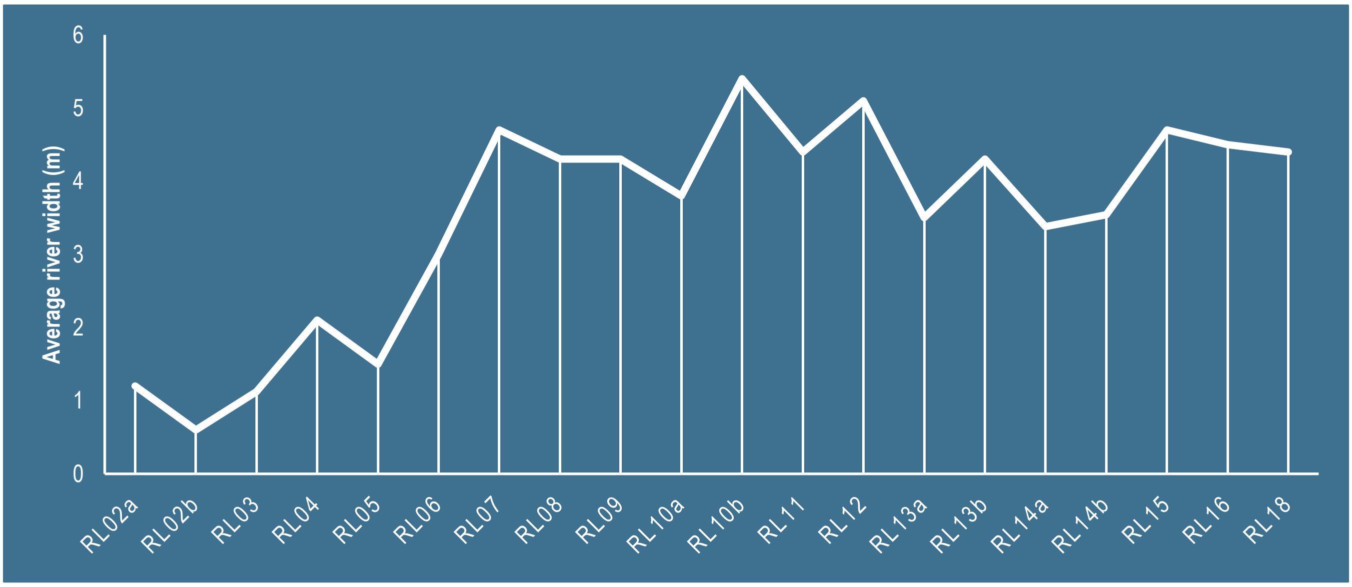

Figure 3: chart showing the average river width recorded for each of the MoRPH survey subreaches from upstream (left) to downstream (right)

3.3. Lateral connectivity to riparian margins

The extent to which the river is hydrologically disconnected from its riparian margins and floodplain was assessed using threshold values of river shape (Average MoRPH width)/Average(water depth + low bank height)) obtained from the MoRPH5 survey and outlined by Gurnell (2021), observations from the River Walkover Survey, and judgements made by the lead surveyor. A total of 8 subreaches/sections were considered to be wholly or partially over deep. Photos and descriptions of each are provided in Table 3.

Table 3; showing photos and description of river sections considered to be over deep based on river shape index and surveyor judgement

Subreach	Photo and description	Subreach	Photo and description
RL01	 Modified reach, partly reinforced channel	RL05	 River confined by Charlton road on right bank. Appears slightly perched with homogenous banks and considered likely to have historically been realigned to follow edge of field and managed for drainage.
RL02b	 Over deep with trapezoidal banks where adjoining gardens and Charlton Road	RL09	 Trapezoidal and reinforced banks. River appears slightly perched at lower end suggesting historical realignment.
RL03	 Likely modified course of river along Charlton road with trapezoidal banks & homogenous bed.	RL10a	 Obviously reshaped banks in places and resectioned with weirs through West Dean gardens
RL04	 River confined by wall and road at upstream end with modified steep reshaped left bank through horse paddock.	RL18	 Historically realigned and right bank raised as river flows past Mid Lavant.

3.4. MoRPH5 River Condition Indices

This sections reviews the 32 river condition indicators derived from the MoRPH5 field survey and provide a measure of the naturalness of the river's morphology, sedimentation, and vegetation structure (positive indicators) and the extent and severity of human interventions (negative indicators). The indicators are presented under four categories: bank top (<10m of the river), bank face, water margin, and channel bed.

3.4.1. Bank top (Indicators B1 to B5)

The scores for each of the five bank top indicators against the maximum likely positive or negative (-4) scores are provided in Figure 3.

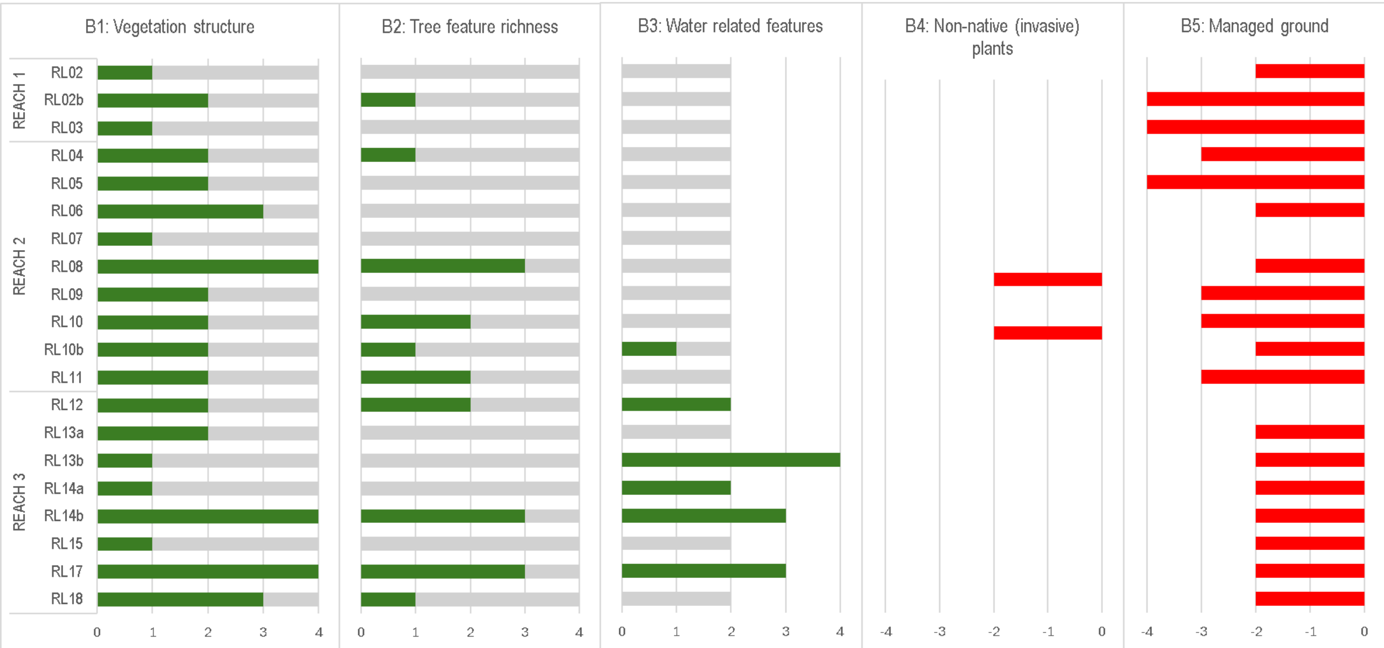

Figure 4: Charts showing the positive (green bars) and negative (red bars) indicator scores for the bank top across each of the surveyed subreaches. Grey bars show maximum expected positive score for the river type.

The majority of subreaches had managed ground within 10m of one or both bank tops (indicator B5) and included pasture, arable, transport, and permanently vegetated recreation. Consequently, the vegetation structure (indicator B1) was dominated by short creeping and/or tall herbs and grasses and resulted in the majority of subreaches scoring low to moderate for vegetation structure (indicator B1). The highest habitat complexity was found along RL08, RL14b and RL17 where all five vegetation types (mosses/lichens, short herbs/grasses, tall herbs/grasses, scrub/shrub, and trees) were present or extensive at one or more of the survey modules. Tree features (indicator B2), which included leaning, j-shaped and fallen trees, large wood and tree/shrub branches trailing into the water, were present or extensive in one or more modules in 10 subreaches with the highest diversity of features located along subreaches RL08, RL14b and RL17. Water related features (indicator B3) were confined to the lower subreaches and were largely associated with seasonal out of bank flows that had created side channels or areas of standing water with short or tall wetland vegetation. Two ponds were present within the riparian margins of subreaches RL14a and RL16 and these are likely to hold more permanent value during both the wet and dry phases of the river. Only two subreaches had non-native species present within the surveyed length (indicator B4) and included Cherry laurel that was overshading the channel in RL08 and Pampas grass which is part of the ornamental gardens along RL10a.

3.4.2. Bank face (Indicators C1 to C10)

The scores for each of the 10 bank face indicators against the maximum likely positive or negative (-4) scores are provided in Figure 5.

Figure 5: Charts showing the positive (green bars) and negative (red bars) indicator scores for the bank face across each of the surveyed subreaches. Grey bars show maximum expected positive score for the river type.

Overall, the vegetation structure (indicator C1) along the bank face was better than the bank top with 17 of the 20 surveyed subreaches attaining over half of the maximum expected score for this river type. Subreaches RL07, RL13b and RL14a which all flowed through treeless agricultural land scored the lowest, whilst RL06, RL08 and RL11 had higher than expected habitat complexity owing to the presence of riparian trees, scrub, mosses, short herbs/grass, and tall herbs/grasses growing along the bank face. Tree features (indicator C2) were also more extensive than on the bank top with one or more feature types being recorded in 16 subreaches. The highest diversity of tree features were found along RL03 and RL11 where all seven feature types (large wood, fallen, j-shaped and leaning trees, exposed tree roots, discrete accumulation of organic material, and trailing tree/shrub branches) were present or extensive at one or more of the surveyed modules.

Dual structure riverbanks were present along the majority of subreaches and composed of earth in the upper part and gravel/pebble in the lower part with a few subreaches also containing pockets of organic material and silt. (RL10 and RL17, indicator C5). The majority of the riverbanks were well vegetated and scored low for bare sediment extent (indicator C6) and three subreaches (RL06, RL10, RL14b) had a good balance of vegetated and unvegetated banks attaining a maximum score of 4. Natural bank profiles were present in all subreaches (indicator C3) and comprised steep and gentle which were the most frequently recorded, composite, vertical, and vertical and toe. Over half the subreaches scored $\geq$3 for natural bank profile richness (indicator C4), whilst five subreaches (RL02b, RL03,RL10, RL10b, RL13b) had only one natural profile present.

Three artificial bank profiles were recorded and included a small embankment most likely resulting from stream clearance along subreach RL02b, obviously reshaped banks which were present or extensive on one or both bankside along subreaches RL04, RL09, RL10, RL10b and poached banks which were extensive along both banks subreach RL15. Reinforced bank materials (indicators C8 and C9) were present along eight subreaches and were associated with bridge abutments (RL04, RL09 and RL10b), weirs (RL10), remnant structures (RL07, RL11, RL18), outfall pipe (RL03) and metal shuttering (RL10). Two non-native (invasive) plant species were recorded at trace abundance within two subreaches and included Japanese knotweed (sapling) in subreach RL08 and pampas grass in subreach RL10a.

3.4.3. Water margin (Indicators D1 to D5)

The scores for each of the five water margin indicators against maximum likely positive and negative (-4) scores are provided in Figure 6.

Figure 6: Charts showing the positive (green bars) and negative (red bars) indicator scores for the water margin across each of the surveyed subreaches. Grey bars show maximum expected positive score for the river type.

The extent of vegetation along the water margins (indicator D1) was generally high and comprised of terrestrial herbs and grasses in Reach 1, and a mixture of terrestrial and aquatic plants along Reaches 2 and 3. Subreach RL04 had the lowest cover of vegetation owing to shading by bankside trees and potential clearance of the river to reduce flood risk at Charlton. Morphotype richness (indicator D2), which was adapted to include the presence of both aquatic and terrestrial forms of liverworts/mosses/lichens, broad-leaved, emergent linear-leaved, and amphibious (plants rooted to the bank but interacting with the channel), was generally high (≥2) for all subreaches within Reaches 2 and 3. Other than a small toe being present along subreach RL03, no physical features (indicators D3 and D4) were recorded in Reach 1 which is unsurprising given that this reach is unlikely to sustain flow for more than a few months of the year. Downstream of here, features indicative of sediment supply and storage were present and included fine and course sediment bars (8 subreaches), stable and eroding cliffs (7 subreaches) and benches and berms (5 subreaches). The highest diversity of marginal features was observed in subreaches RL11 and RL18.

Artificial features (indicator D5) were recorded along 11 subreaches and included outfall pipes (RL03, RL04) and jetties and/or deflectors associated with structures (RL04, RL07, RL09, RL10, RL10b) or fencing (RL06, RL08, RL09, RL11, RL12, RL14b).

3.4.4. Channel bed (Indicators E1 to E12)

The scores for 11 of the 12 channel bed indicators for each subreach against the attainable positive or negative (-4) scores are provided in Figure 7. The results for non-native (invasive) plant species indicator (E11) are not shown as there were none recorded within the channel bed.

In-channel vegetation showed a general increase in richness (indicator E1) from upstream to downstream with highest richness observed in subreaches RL11, RL14a and RL14b where mosses/lichens/liverworts, and fine-, linear-, and submerged-leaved morphotypes were all present. Tree features (indicator E2) were present in the majority of subreaches and comprised river shading (14 subreaches), discrete accumulation of organic materials (7 subreaches), submerged tree roots (RL03, RL05, RL08 and RL10), saplings/trees growing from submerged riverbed (RL14b), fallen trees (RL04, RL08, RL11, RL12 and RL14b), and large wood that was present behind a fallen tree in RL12.

The channel substrate (indicator E6) was dominated by gravel/pebble, cobble with localised areas of finer substrates (earth, sand and silt), bedrock (RL16) and organic materials. Channel bed siltation (indicator E7) was present in all subreaches and filamentous algae (indicator E12) was observed at variable abundance along all subreaches other than RL02, RL12 and RL17. Flow (indicator E3) was typical of course substrate rivers being dominated by unbroken standing waves and/or rippled surface, with some nice chutes present along subreaches RL08, RL12, RL14a and RL15 where woody vegetation was pinching the channel. Low hydraulic diversity was observed along RL03 and RL04, likely due to these channels being cleared of vegetation to reduce flood risk. A total of five physical features were present across the subreaches of which riffles were the most frequently recorded. Pools were present along eight subreaches indicating variable bed levels and mid-channel vegetated and unvegetated bars were also present in subreaches RL06, RL11, RL14a & b, and RL15.

Artificial features including a culvert (RL04), remnant sluice structure (RL07), a weir (RL10), footings of a remnant structure (RL18), and large trash (RL06, RL08 and RL16) resulted in these subreaches attaining negative scores against indicators E8, E9 and/or E10.

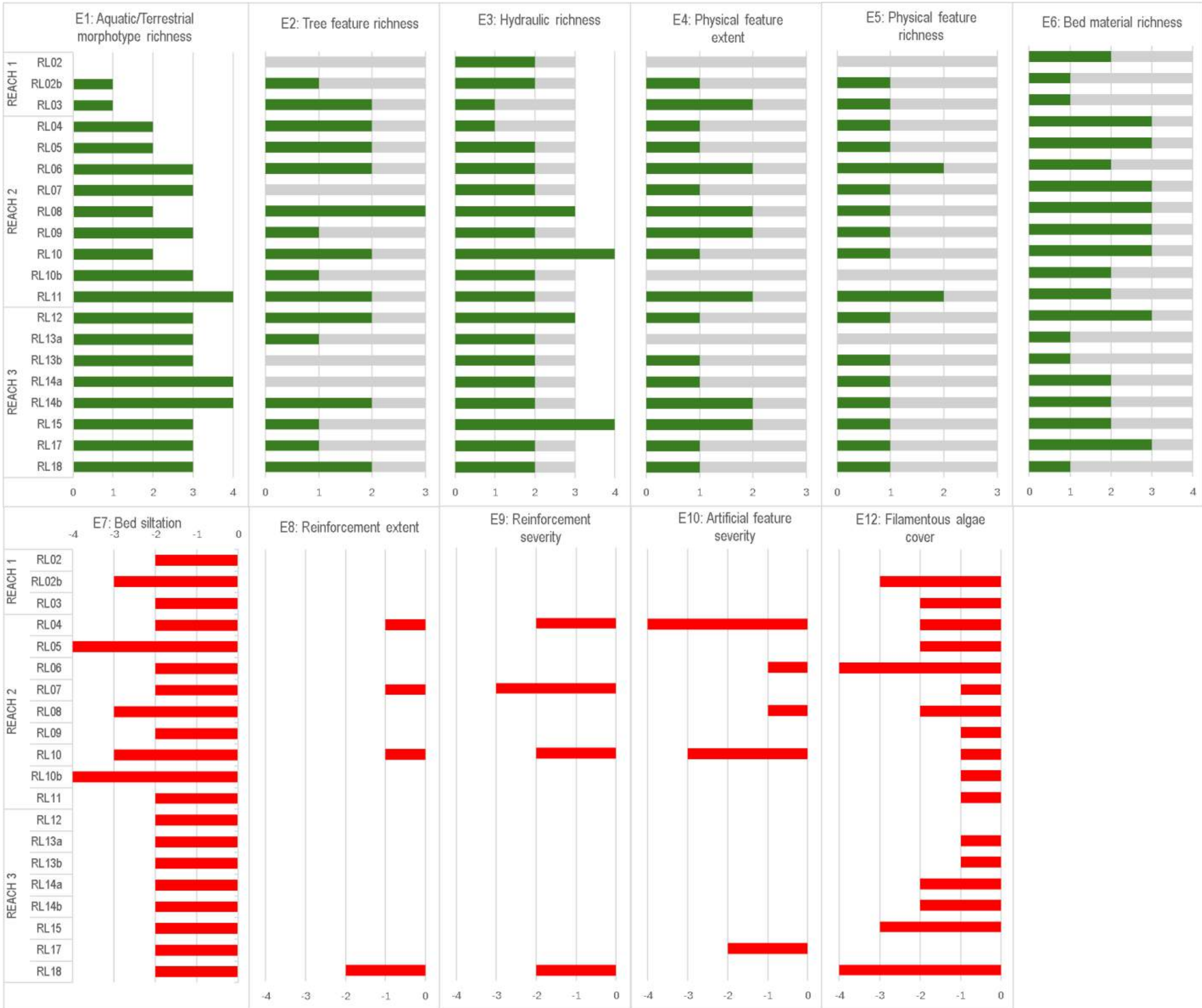

Figure 7: Charts showing the positive (green bars) and negative (red bars) indicator scores for the channel bed across each of the surveyed subreaches. Grey bars show maximum expected positive score for the river type.

3.5. MoRPH5 Preliminary and final condition scores

The average numerical scores across 19 positive and 13 negative indicators for each subreach subject to a MoRPH5 survey are provided in Figure 8. This shows that positive indicator scores ranged from a low of 0.6 (RL02b) to a high of 2.79 (RL14b) with nearly half of the subreaches attaining an average positive indicator score of >2. The average scores across negative indicators ranged from -0.23 (RL12) to -1.92 (RL10) with Reach 2 subreaches generally scoring lowest suggesting this reach is most impacted by human intervention.

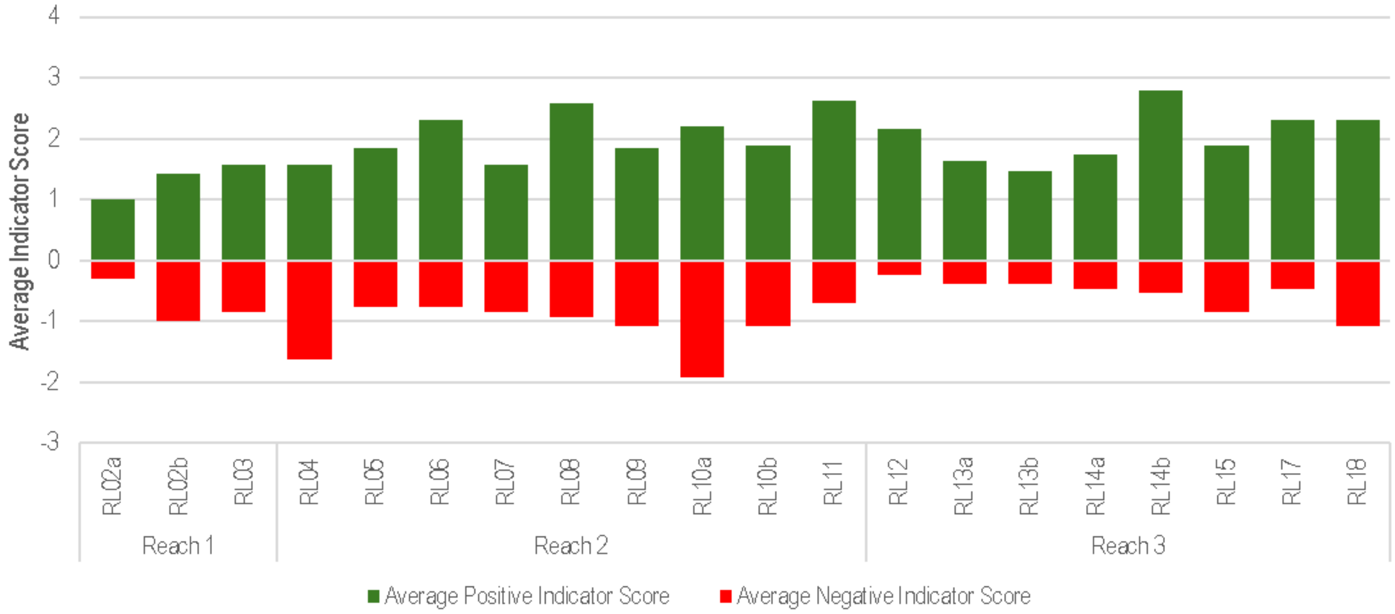

Figure 8: Chart showing the average positive and average negative indicator scores for each of the subreaches subject to a MoRPH5 survey.

Combined, these scores resulted in preliminary numerical condition scores that ranged from -0.04 (RL04) to a high of 2.25 (RL14b) (Figure 9). Using the lower threshold values for allocating preliminary scores to final condition scores based on the river type and whether the subreach is considered over deep, six subreaches scored 'fairly good', seven subreaches score 'moderate', five scored 'fairly poor', and two subreaches were classified as 'poor' (RL04 & RL10a).

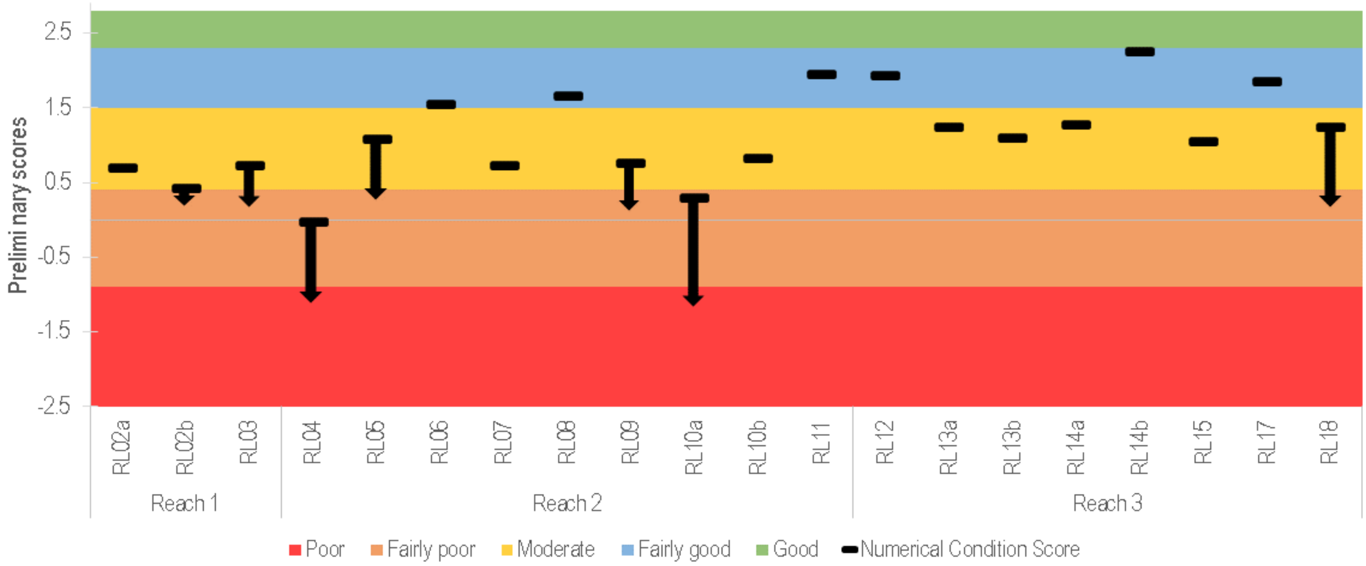

Figure 9: Chart showing the preliminary condition scores against threshold values for condition classes. Arrows denote a drop in final condition by one class for over deep subreaches.

3.6. Riparian land use and buffers strips

The dominant riparian land uses present along the upper Lavant by length of surveyed bank is provided in Figure 10. This shows that the majority of the river flows through agricultural land of which 4km is bounded by pasture and 1.7km and 0.9km is bounded by arable land on the left and right bank respectively. Other modified habitats including roads, urban greenspace, residential gardens, and the parkland gardens at West Dean, which together accounted for 20% and 33% of the land uses present on the left and right banks. Natural habitats (woodland and tall herb/rough grassland) were relatively scarce and fragmented, making up just 15% and 11% of the riparian land uses present along the river corridor.

Riparian buffer strips (unmown or unmanaged areas along the edges of the river) were present along 3.3km (44%) and 2.5km (32%) of the left and right banks of the river that flowed through managed land (agricultural, urban, gardens). This included all arable land and 63% and 21% of the total length of river that flowed through pasture on the left and right bank respectively.

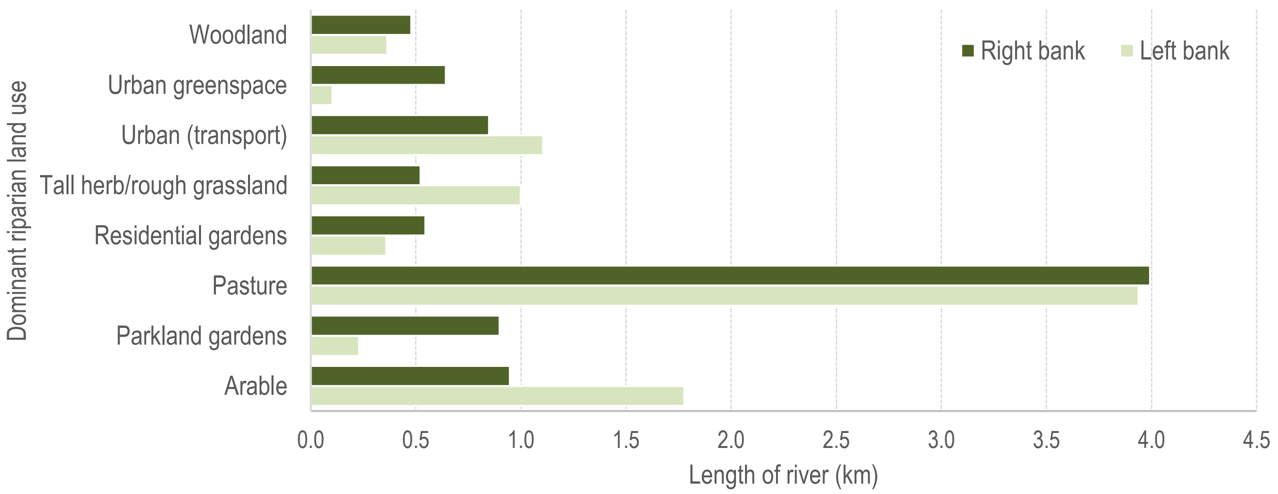

Figure 10; Chart showing the dominant land uses present along the river corridor by length of surveyed bank.

3.7. Riparian trees

Riparian trees provide multiple benefits to river habitats including channel shading to reduce water temperatures, structural diversity to the channel and riparian protection against rural land management, and it is generally recommended that around 40% cover along river sections provides a good balance in chalk river systems. The number of walkover survey sections with different levels of tree cover (from low to high) is shown in Figure 11 and the distribution of tree cover is provided in Figure 12. This shows that over a third of the sections assessed had no or isolated trees on both bank sides, seven had occasional clumps of trees present on one or both bank sides and four had semi-continuous trees on one or both bank sides. Ash die back was recorded in two sections (RL12 and RL14).

Photos showing habitats present along the riparian corridor are provided in Plate 4.

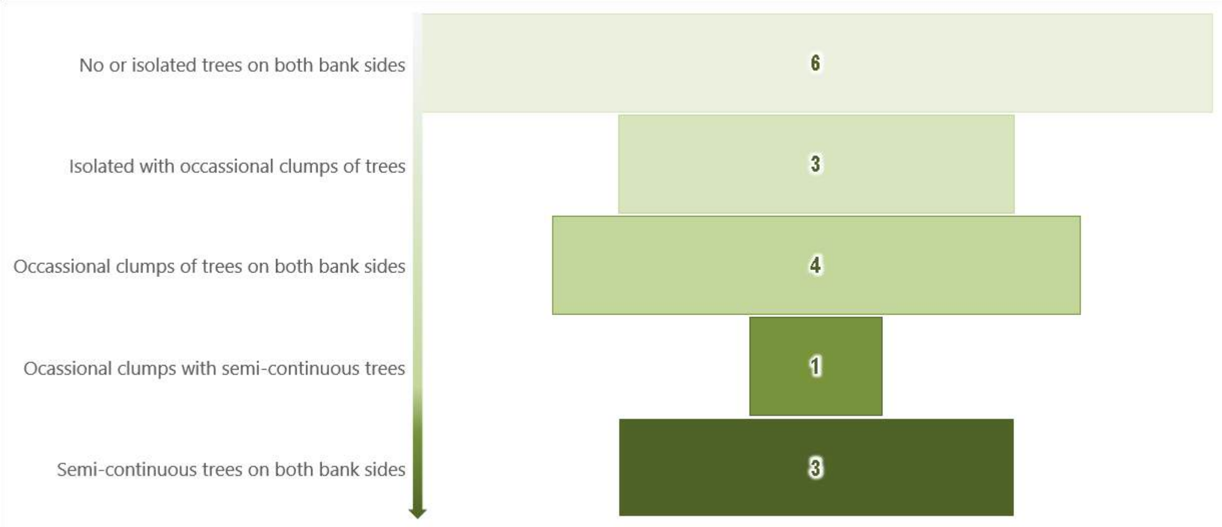

Figure 11: Chart showing the number of river sections classed by the presence and extent of riparian trees

Plate 4: Photos showing riparian habitats encountered during the survey from left to right top to bottom: Improved grassland at source (upstream of RL01); allotments (RL01); line of trees (RL03); horse pasture (RL04); transport infrastructure (RL04); pasture and mown grass (RL09);cattle pasture (RL15); arable margins (RL12) and wide margin of pasture field (RL18).

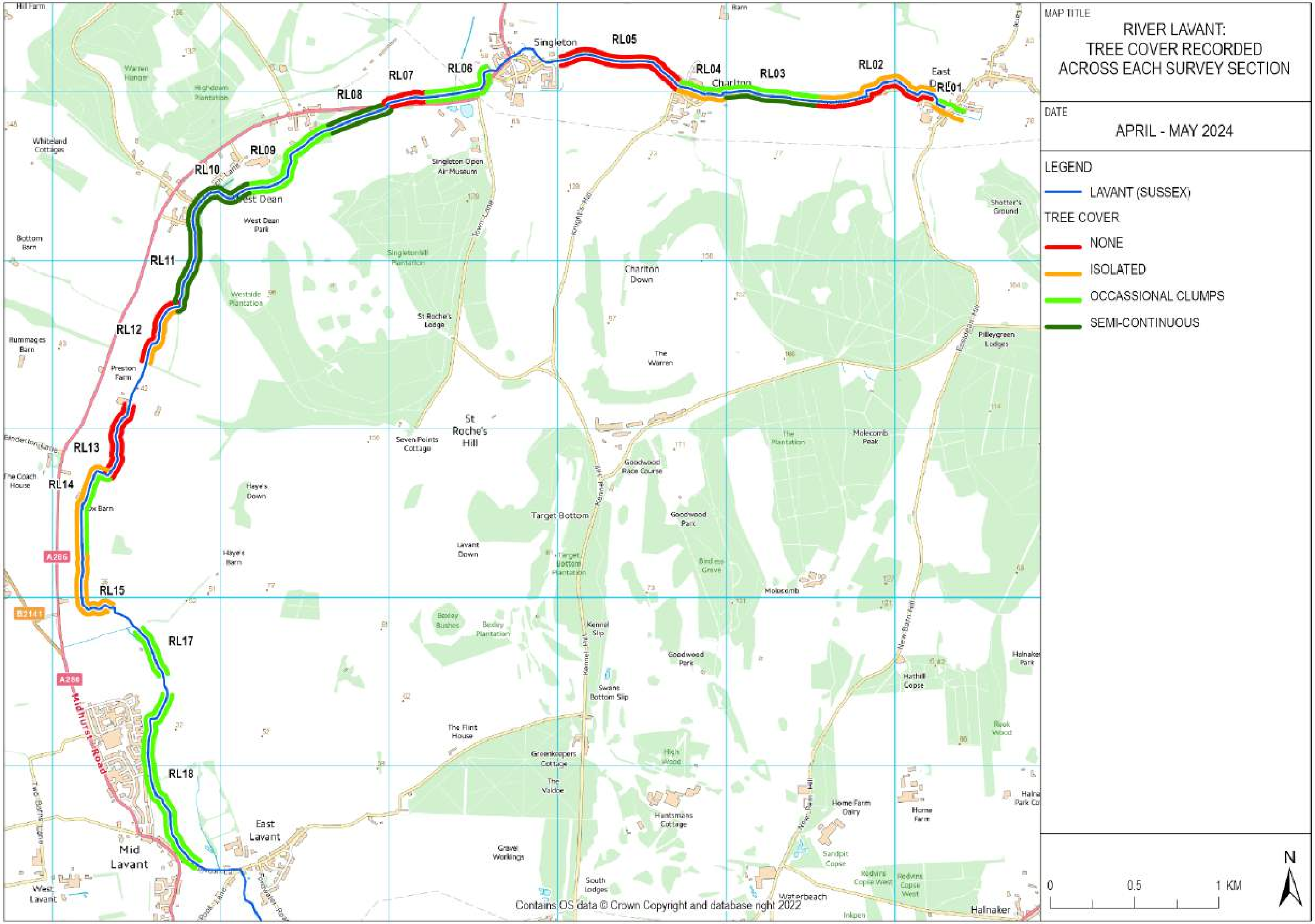

Figure 12: Map showing the recorded class of tree cover on left and right bank for each survey section.

3.8. Macrophytes

A list of macrophytes recorded during the survey are provided in Table 4 and, other than algae and bryophytes, were identified to species or genus level, where possible. This is not intended to be a comprehensive list of all species present as the surveys were undertaken outside of the optimum period for aquatic plants (1st June to 30th September) and were limited to observations made along the bank top. However, the species provide a rough guide to variations in flow and community types that are present along the upper Lavant at the time of survey.

A total of 17 macrophytes were observed and included species falling within six functional groups: umbellifers, batrachids (water crowsfoot), peplids (starworts), plaurocarpus mosses, red or green filamentous algae, and encrusting algae. The most abundant macrophyte was filamentous algae, which was present or extensive in all but two subreaches (RL09 and RL16) and was observed at the springs that arise in the fields east of East Dean, upstream of RL01. This group is generally a negative indicator when present at high abundance (>15% cover /100m), suggesting elevated concentrations of inorganic nutrients. Also of note was the widespread presence of what appeared to be sewage fungus, although no formal identification was undertaken during the survey.

Other than filamentous algae, no macrophytes were encountered between East Dean and Charlton (Reach 1) where channel vegetation was dominated by terrestrial herbs and grasses including *Alopecurus geniculatus* and indicative of communities in intermittent streams. From Charlton (Reach 2) to Singleton, the vegetation community shifted to include species such as *Veronica anagalis-aquatica, Apium nodiflorum* and *Phalaris arundinacae* that were growing alongside terrestrial herbs and grass and are more typical of winterbourne type communities. *Lemanea spp*, was also observed which is a positive indicator for flow. From Singleton, species including *Ranunculus peltatus*, *Oenanthe crocata* and *Callitriche platicarpa* were observed, suggesting springs, and likely the Southern Water discharge, are adding vigour to the river here. From subreach RL12 (Reach 3), the channel emerges into a wide floodplain and the vegetation community was dominated by *Oenanthe crocata*, *Ranunculus peltatus* with some isolated patches of *Berula erecta*. One non-native (invasive) macrophyte *Mimulus spp*. was recorded along both banksides of subreach RL10b.

In terms of taxa diversity, the highest number of both species and functional groups was observed at Singleton and West Dean, whilst the lowest diversity was observed along the intermittent Reach 1. Photos showing examples of macrophytes encountered during the survey are provided in Plate 5.

Plate 5; Photos showing examples of macrophytes observed during the walkover survey: from left to right top to bottom; Cladophora (blanket weed, RL10a, sewage fungus (RL13b); Hildenbrandia (RL10a); Iris pseudacorus (RL10b); Phalaris arundinacae & Oenanthe crocata (RL12a): Ranunculus beds (RL10b and RL13b); Ranunculus peltatus, Rorippa aquaticum & Apium nodiflorum (RL13b); Ranunculus beds (RL13b); Oenanthe crocata (RL17).

Table 4: showing macrophytes and their functional group (based on the ecological classification defined under WFD, Environment Agency 2012) that were observed in each survey sections/subreach.

Common Name	**Latin Name**	**FG**	**RL 01**	**RL 02a**	**RL 02b**	**RL 03**	**RL 04**	**RL 05**	**RL 06**	**RL 07**	**RL 08**	**RL 09**	**RL 10a**	**RL 10b**	**RL 11**	**RL 12**	**RL 13a**	**RL 13b**	**RL 14a**	**RL 14b**	**RL 15**	**RL 17**	**RL 18**
Fool's watercress	*Apium nodiflorum*	8					1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Lesser water parsnip	*Berula erecta*	8																1			1		
Various leaved water starwort	*Callitriche platicarpa*	6						1															
Encrusting algae	*Hildenbrandia spp*	20								1			1	1	1								
Bryophytes	*Incl. Brachythecium & Fontinalis spp.*	21					1		1		1	1	1	1	1	1	1	1	1	1	1	1	1
Yellow flag iris	*Iris pseudacorus*											1		1		1							
Red algae	*Lemanea spp.*	19					1	1	1								1		1	1			1
Water mint	*Mentha aquatica*													1	1								
Monkey flower	*Mimulus spp.*													1									
Hemlock water dropwort	*Oenanthe crocata*	8							1					1		1	1	1	1	1		1	1
Reed canary grass	*Phalaris arundinacae*							1	1				1	1	1	1	1	1	1	1	1	1	1
Pond water crowsfoot	*Ranunculus peltatus*	18							1	1		1	1	1	1	1		1	1	1	1	1	1
Watercress	*Rorripa nasturtium aquaticum*							1	1			1				1		1			1		
Wood club rush	*Scirpus sylvaticus*													1	1								
Water figwort	*Scrophularia auticulata*											1		1									
Filamentous unbranched green algae and/or Blanket weed	*Spirogyra/Mougeotia/ Zygnema and/or Cladophora/ Rhizoclonium agg*	19	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Blue water speedwell	*Veronica anagallis-aquaticus*						1	1	1	1		1	1	1	1			1					
Sewage fungus			1			1		1		1		1								1			
Number of observed taxa			**1**	**1**	**1**	**1**	**5**	**7**	**9**	**5**	**3**	**8**	**7**	**13**	**9**	**8**	**6**	**9**	**7**	**7**	**7**	**6**	**7**
Number of functional groups			**1**	**1**	**1**	**1**	**3**	**1**	**5**	**3**	**3**	**4**	**5**	**5**	**5**	**4**	**3**	**4**	**4**	**4**	**4**	**4**	**4**

3.9. Invasive non-native plants

A total of eight non-native (invasive) plants were recorded during the surveys (Table 5). All of these species are listed on the Global Invasive Species Database (GISD) for Great Britain that covers alien invasive species that threaten native biodiversity. Two species; Japanese knotweed (*Fallopia japonica*) and Cotoneaster spp. are listed under Schedule 9 of the Wildlife and Countryside Act, 1981 (as amended) meaning that is an offence to plant, or otherwise cause to grow these species in the wild. Three species; Japanese knotweed, *Gunnera spp* and Monkey flower *(Mimulus spp)* are listed as high or moderate impact under the WFD UKTAG meaning they pose a risk to surface waterbodies and their ecological status.

A map showing the distribution of species is provided in Figure 13.

Table 5: Non-native (invasive) plant species recorded during the walkover and RCA survey. Showing designated status, number of records and locations (reach and subreach).

Species	Photo	Status	N Records	Reach	Subreach
Japanese knotweed ***Fallopia japonica***		WCA Sch 9 WFD UKTAG High Impact GISD GB	1 (sapling)	2	RL08
Cotoneaster spp		WCA Sch 9 GISD GB	2	1 & 2	RL01 RL10a
Monkey flower (*Mimulus spp*)		GISD GB WFD UKTAG Moderate Impact	1	2	RL10b
Gunnera spp (to be confirmed)		GISD GB WFD UKTAG High Impact	1	2	RL10a

Species	Photo	Status	N Records	Reach	Subreach
Cherry laurel, *Prunus laurocerasus*		GISD GB	3	2	RL08
Butterfly bush, *Buddleia davidii*		GISD GB	4	2 & 3	RL08 RL18
Winter heliotrope, *Petasites fragrans*		GISD GB	1	1	RL01
Pampas Grass, *Cortaderia selloana*		GISD GB	1	2	RL10a

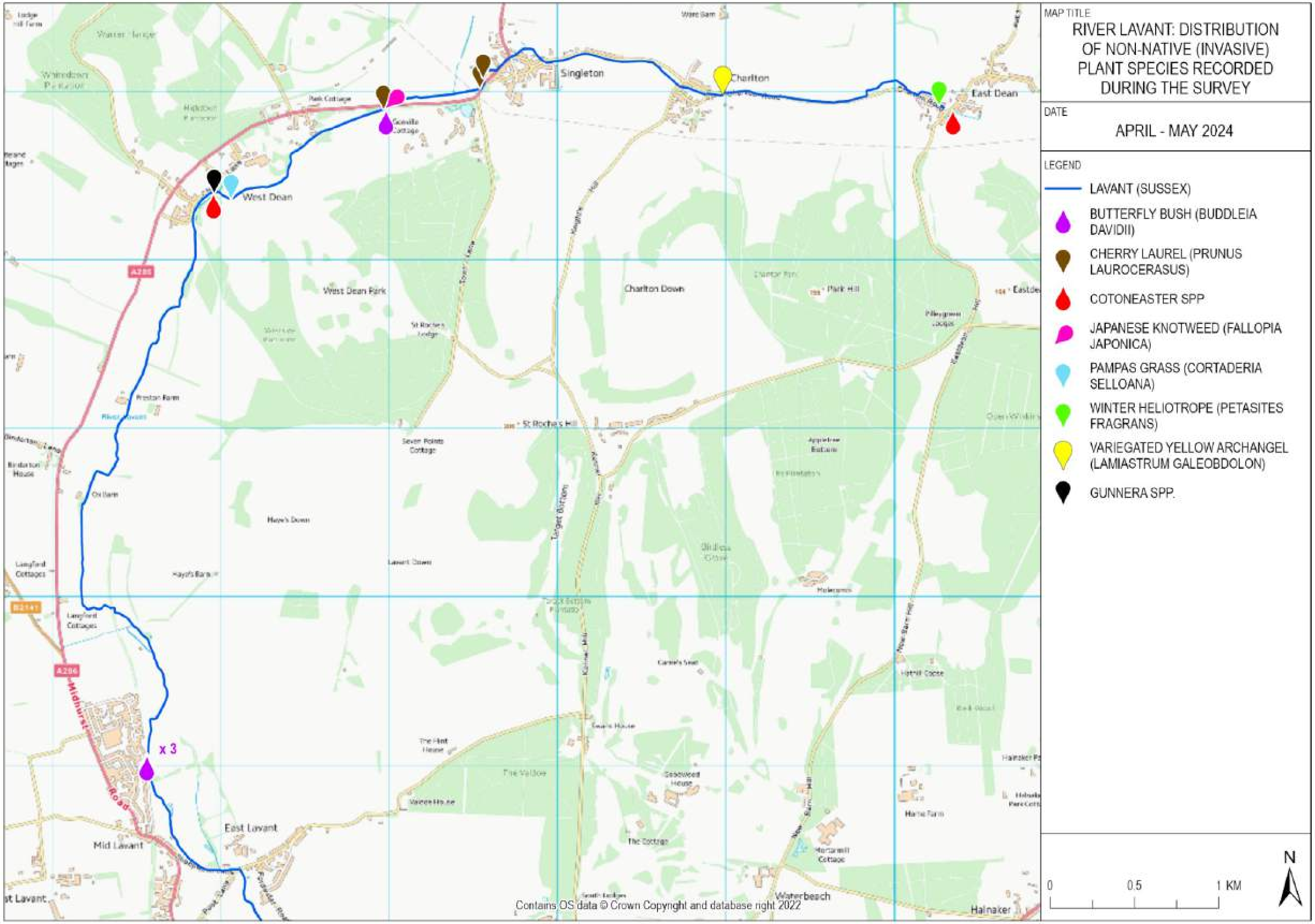

Figure 13: Map showing location of non-native (invasive) plant species recorded during the walkover and RCA survey of the upper River Lavant.

3.10. Modifications

A total of 11 modification types were recorded during the walkover survey and included:

- 13 culverts
- 8 (minor) fords
- 14 outfalls (10 minor, 4 intermediate)
- 5 sections with wholly or partially poached riverbanks
- 8 sections partially or wholly over deepened
- 9 sections partially or wholly reprofiled (reshaped)
- 18 (minor) bridges
- 7 weirs (including remnant/undercut structures)
- 12 sections with reinforced banks present
- 2 sections with embankments present
- 2 sections with reinforced bed

Photos showing examples of each modification type are provided in Plate 6 and descriptions and locations of each are provided in the site assessment reports (Appendix A).

Plate 6 Photos showing examples of modifications recorded along the upper River Lavant from left to right, top to bottom: weir (RL10), major deflector (old sluice, RL07), minor outfall and reinforced left bank (RL06), major deflector (undercut weir, RL08), minor bridge,weir and reinforced banks (RL10), intermediate outfall (RL06), minor ford (RL02), minor bridge and minor (kiddies) weir (RL07), reinforced banks (RL06), poached river banks (RL15), culvert and resectioned banks (RL09), intermediate outfall (RL06).

Together, these modifications resulted in four sections being classified as severely modified, seven sections as significantly modified, four sections as obviously modified, and two sections as predominantly unmodified (Figure 14). The impact of modifications on the final numerical condition scores can be seen in Figure 15 which shows subreaches with more modifications generally have lower numerical condition scores, reflecting poorer habitat quality.

A map showing the modification scores for each river section is provided in Figure 16.

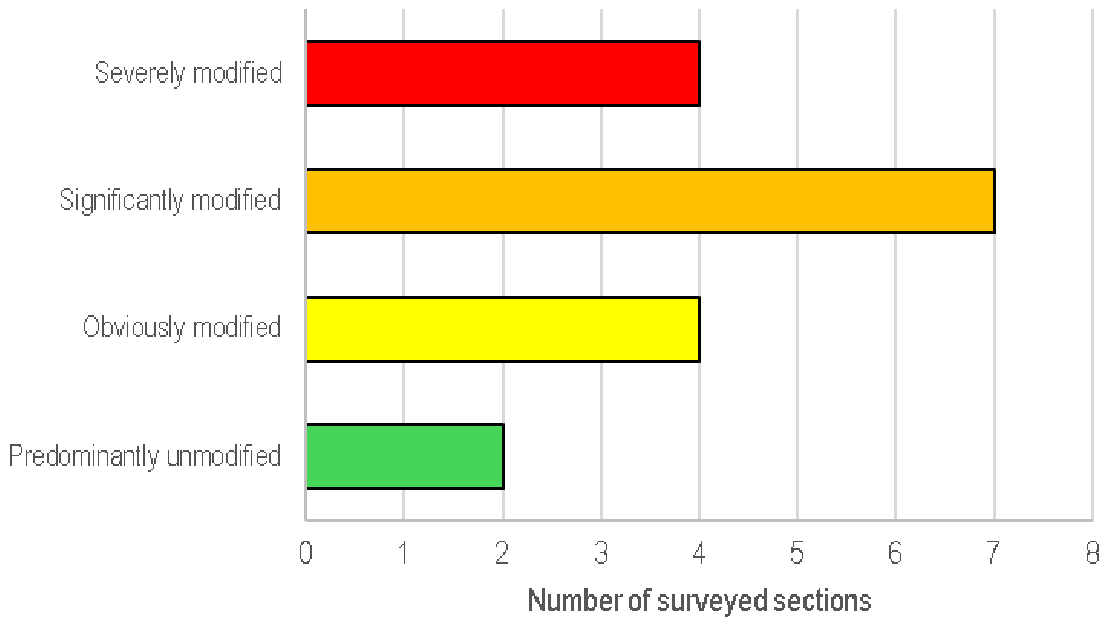

Figure 14: Chart showing the number of subreaches classified under each Habitat Modification Class

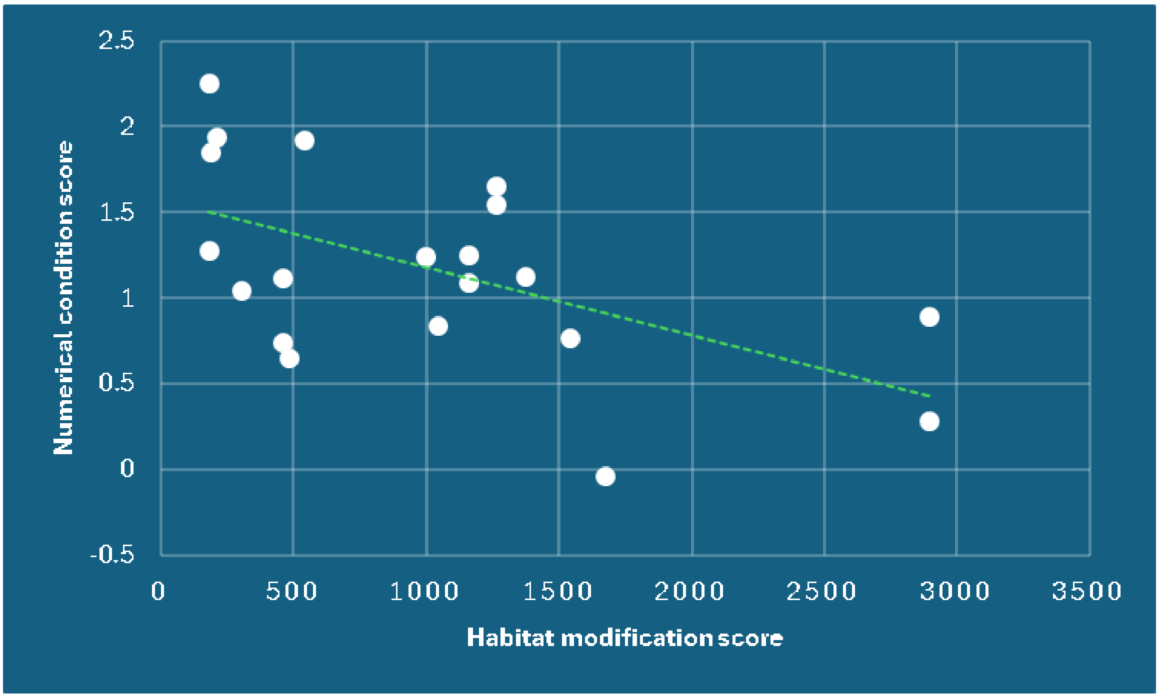

Figure 15: Chart showing the relationship between habitat modification scores (lower score equates to fewer and/or less severe modifications) and the numerical condition score attained from the River Condition Assessment.

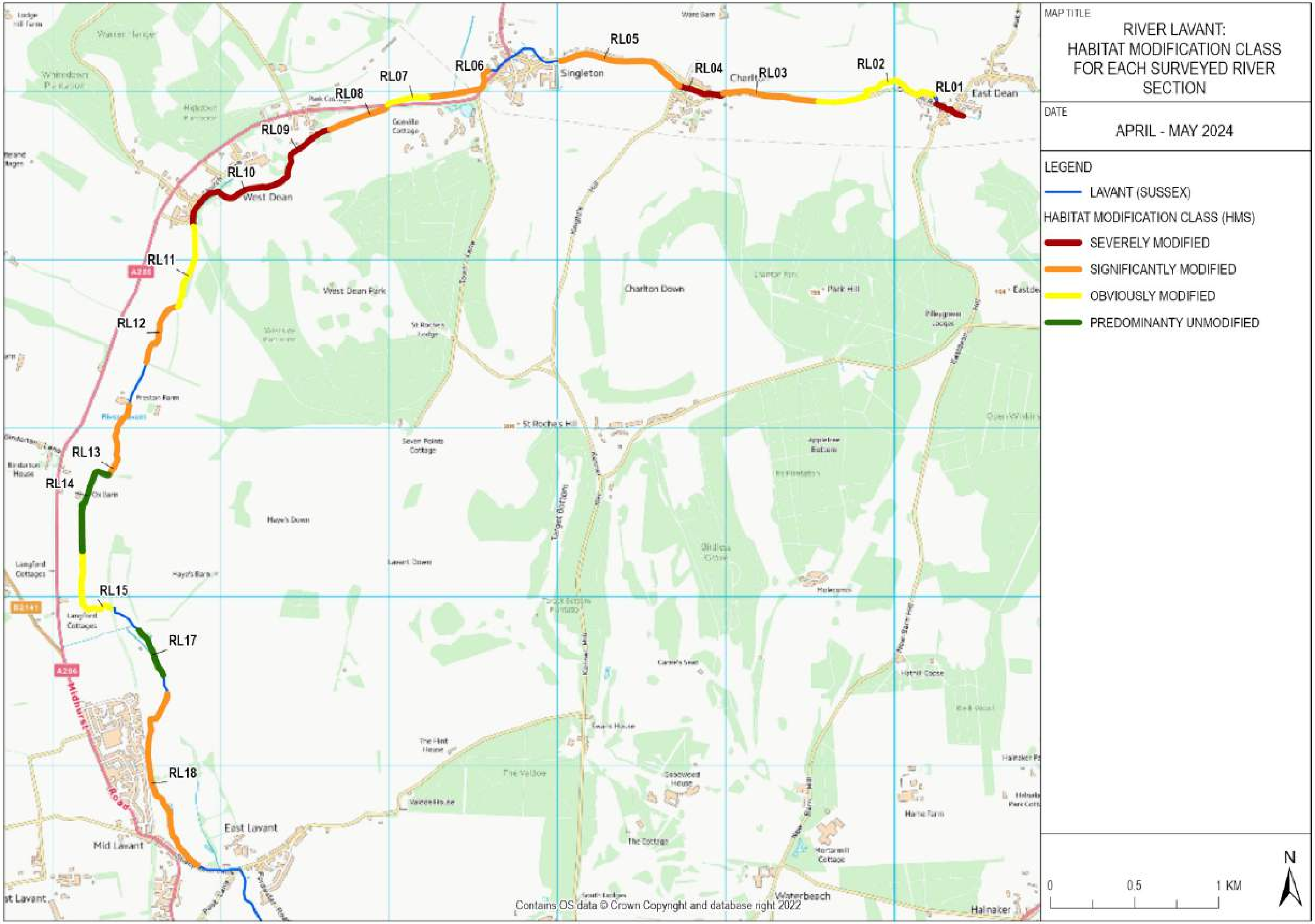

Figure 16: Map showing the habitat modification class for each section of the upper River Lavant that was subject to a river walkover survey.

3.11. Main impacts recorded during the walkover survey

There were a number of different impacts recorded along the upper River Lavant that were considered to be limiting the ecological health of the river. These included point and diffuse sources of pollutants, management or neglect of riparian margins, modifications, and invasive non-native species. These issues are often interlinked with one causing or exacerbating the effects of another, and, in most cases, it is the cumulative effect of multiple factors present at a site that are impacting the health and resilience of the river. A summary of the main impacts are provided below and a checklist detailing those that are present is provided in Table 6.

3.11.1. Pollution pathways

Pollution was recorded as a major impact on the river for all sections subject to a walkover survey and whilst no formal water quality testing was carried out, observations of extensive filamentous algae and sewage fungus suggest the health of the river is being impacted by pollution. The following pollution pathways were considered likely to be contributing to poor water quality (Plate 7):

- Sewage issuing from drains at 11 locations along sections RL01, 02, 05, 07, 09, 10 and 17 with discoloured and/or foul-smelling water noted along sections RL01, 02, 05 and 10.
- Open drain cover submerged within riverbed in section RL13b.
- Horse manure pile on left bank top of river in section RL11.
- Diffuse pollution pathways from cattle and horse grazed pasture (RL04, 06, 11, 15).
- Diffuse/sediment pollution from overland flow through oilseed rape fields (RL12, 13a).
- Sediment pollution from muddy fords (RL02a, RL06)

Southern Water were actively pumping from the sewers into tankers to relieve the system at East Dean, Charlton and West Dean Gardens for the duration of the walkover surveys.

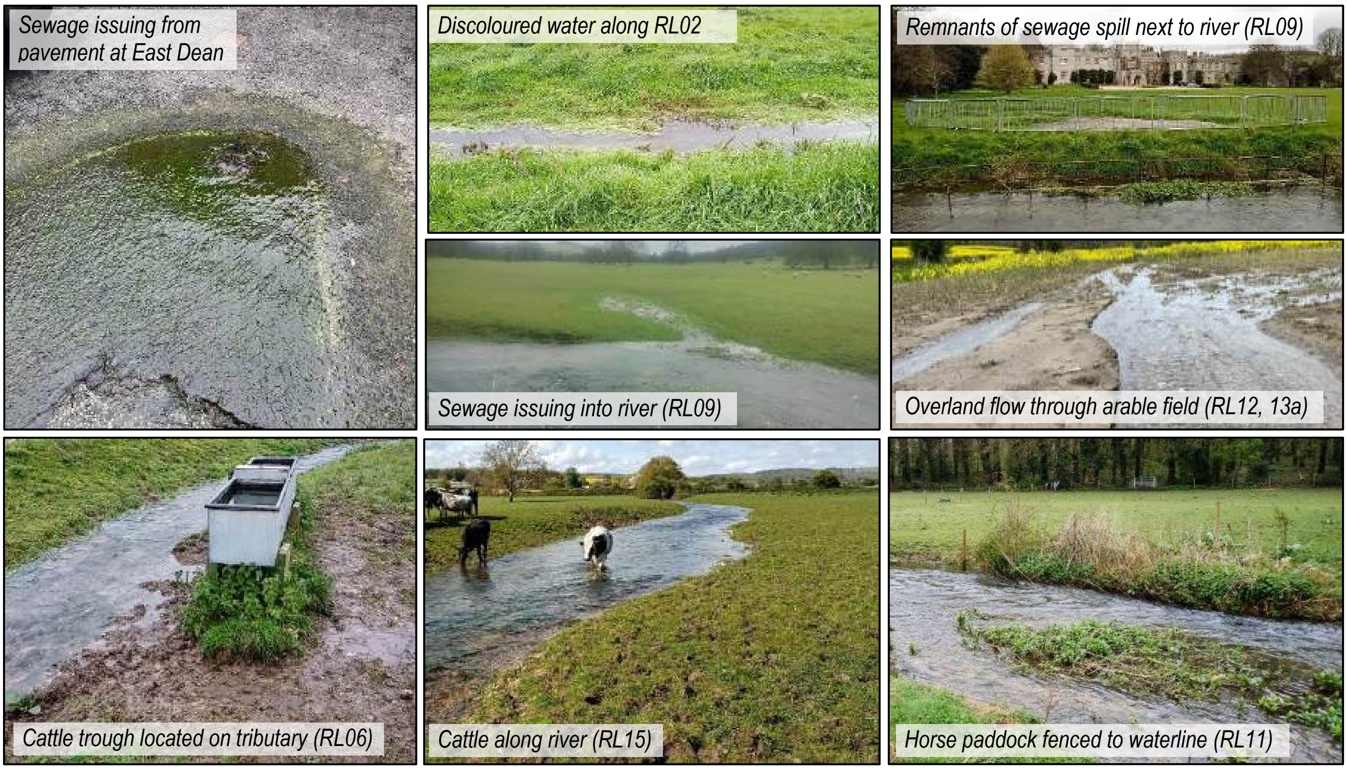

Plate 7; photos showing examples of pollution pathways observed during the surveys.

3.11.2. Riparian management

Diverse and well vegetated riparian margins play an important role in protecting the river from diffuse pollutants (and sediment), help protect riverbanks from erosion, and can influence geomorphological diversity by altering flow, sediment composition, and river levels that create microhabitats and resilience during low flows. The following observations were made during the survey which are considered to be limiting the quality of riparian margins along the upper Lavant:

- Mowing of marginal vegetation up to, or close (<1m) of the water's edge was recorded along eight sections and was most often associated with river sections that flowed through residential gardens, recreational sites, or along roads (Plate 8a).
- Nine sections were considered to be impacted to some degree by grazing and/or livestock poaching and included three sections where livestock had access to a significant amount of the river (RL09, 13b & 15) and one section (RL08) where damage had occurred along localised sections of the watercourse. The remaining sections (RL03, 04, 06, 11 & 14a) were where livestock fencing was positioned close to the bank top or water's edge and considered to be limiting marginal habitat (Plate 8b).
- Common nettle along the riverbanks was widespread but was present in significant patches along eight sections (Plate 8c). Often associated with nutrient enrichment and bare areas trampled by livestock, the plant spreads by rhizomes to form dense patches, suppressing the growth of more diverse flora. It will also die back overwinter decreasing the resilience of the riparian margins to capture storm run-off from adjacent land.

Plate 8; a) showing mown banks along Charlton Road (RL05); b) livestock poaching (RL09); c) continuous nettle along bank face (RL07)

3.11.3. Trees and scrub

Riparian trees and scrub and their associated woody features provide valuable habitat for aquatic organisms and have an important role in moderating water temperatures and creating physical habitat diversity which increases the rivers resilience to floods, droughts and pollution. Too much shade, however, can be a problem in suppressing growth of aquatic plants that would otherwise provide habitat and buoy water levels during periods of low flow. Eleven subreaches were considered to be limited by the presence and/or absence of bankside trees and scrub and include the following:

- Four subreaches were considered to be wholly or partly impacted by the absence of bankside trees and/or scrub such that the river was under-shaded and had few or no woody features to provide hydrological and physical diversity (Plate 9a).
- Five subreaches were considered to be partly overshaded by trees or by scrub encroachment (Plate 9b).
- The riparian margins along two subreaches were considered to be impacted by dominance of bramble scrub that was limiting diversity of marginal macrophytes and habitats (Plate 9b).

Plate 9 a) under shaded and homogenous (RL07); b) overshaded by trees and scrub (RL14b); c) homogenous scrub on right bank (RL17)

3.11.4. Modifications

Physical modifications were present along all surveyed sections and ranged from small interventions such as fords or fencing over/in the channel, to larger and more impactful alterations such as changes to channel form (over deepening, realignment), built structures (reinforcements, weirs/sluices) for water management or riverbank protection, and bridges/culverts to facilitate infrastructure. Those that are considered to have a significant impact on the water environment and/or do not necessarily support important infrastructure are summaries below:

Over deepening and channel reshaping

Over-deep, or incised, channels were present along nine subreaches and reduce connectivity with their floodplain. Steep banks limit the ability of marginal, transitional, habitats to form reducing refuge and breeding sites for aquatic wildlife. This lack of habitat structure also increases the risk of aquatic organisms being swept downstream during high flow events, and, if passing over or through in-channel barriers, disconnect fish populations, reducing their abundance and diversity within the upstream areas. Over deepening may also increase downstream flood risk, again caused by the limited lateral connectivity with the floodplain other than during extreme flood events.

Weirs and remnant structures

Weirs and remnants water control structures were recorded along four subreaches and can impact rivers in three major ways. Firstly the river system becomes fragmented, disrupting the continuity of habitat used by aquatic wildlife and restricting the movement of species, separating them from habitats and natural resources required for their survival or the completion of their life-cycle. Fragmented habitats are also less resilient, reducing the ability of species to re-colonise areas following impacts such as pollution incidents and limiting essential gene flow required for healthy populations.

Secondly, in-channel structures impound water, drowning out habitat, such as riffles, which are critical breeding grounds and habitat for a diverse range of species. As dynamic systems, naturally functioning rivers balance the transport of sediment through erosion and deposition processes, creating a mosaic of habitats suited to all life stages of aquatic wildlife. Weirs stop this natural tendency for change, creating a uniform, static environment. Upstream of structures, an over deep river channel is formed in the impounded area, which is unlikely to support appropriate fish communities and alters the temperature regime, oxygen content and cause sediment build up.

Finally, the natural process of sediment movement is prevented by weirs which trap it in once place smothering the riverbed and impacting its function as a feeding and breeding area. In a natural system, sediment is shaped and accumulated by flow regimes, creating dynamic and evolving habitats which support high diversity of species.

Bed & Bank Reinforcements

Reinforced banks were present along 12 sub-reaches and included short sections of river (<2m) (Plate 10a), shuttering of or walls along riverbanks through urban areas and longer stretches associated with bank protection or historic water gardens (Plate 10b). In all cases, reinforcements were made from impermeable materials which reduce natural sediment delivery and deposition and make the watercourse more vulnerable to extremes of flow. The hard surface of these reinforcements deflect river flows but do not remove and on the velocity from them meaning that erosion pressure is moved to the next area of soft bank. If surfaces are angular, they can produce eddying flows which degrade soft bank material, often eroding it from behind the reinforced area, once this occurs the reinforcement accelerates flow velocity in the void, dramatically exacerbating the rate of erosion beyond that which would occur naturally.

Likewise, bed reinforcements which were recorded in two sections (RL10a, & 18, Plate 10c) create a resistant layer which reduces the ability for specialist invertebrate species to access water-filled interstices in sediments which are important refuge areas during the dry phase. Where bed reinforcement encroaches into the water column, these impound water and trap sediment, altering habitat diversity and river dynamics, and can create artificial flow regimes (such as the creation of eddy's) which can exacerbate erosion.

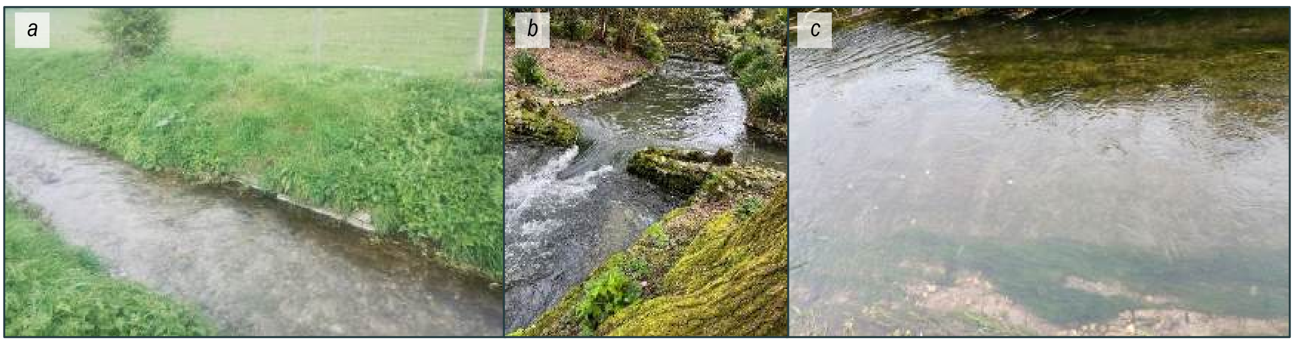

Plate 10 a) small bank toe reinforcements (RL03), b) major bank and partial bed reinforcements (RL10a); c) bed reinforcements associated with old footbridge (RL18)

Table 6: showing impacts recorded for each surveyed section/subreach of the upper River Lavant including those contributing to MoRPH5 negative indicator scores and RHS Habitat Modification Scores.

								Water quality				Modifications												
								Point																
Subreach	Mowing	In-channel clearance	Grazing	Nettles	Under shaded by trees	Over shaded by trees	Scrub encroachment	Sewage	Other	Diffuse	Invasive Non-native plants	Embankments	Reinforced banks	Reinforced bed	Urban trash	Outfall pipe(s)	Fencing (washed out or within channel)	Weirs	Remnant structures	Culvert/bridge	Ford	Realigned	Reprofiled	Over deep
RL01	1	0	0	0	0	0	0	1	1	1	1	1	1	0	0	1	0	0	0	1	0	1	1	1
RL02a	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	1	1	1	0
RL02b	0	0	0	0	0	0	0	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	1	1
RL03	0	1	1	0	0	0	0	0	0	1	0	0	1	0	1	1	0	1	0	1	0	1	1	1
RL04	1	0	1	1	0	0	0	0	1	1	1	0	1	0	0	1	0	0	0	1	0	0	1	1
RL05	1	0	0	0	0	0	0	1	0	1	0	0	1	0	0	0	0	0	0	1	0	0	1	1
RL06	1	0	1	1	0	0	1	1	0	1	1	0	1	0	1	1	1	0	0	1	1	0	0	0
RL07	0	0	0	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0
RL08	1	0	1	1	0	1	0	0	0	1	1	0	1	0	1	0	1	1	0	1	0	0	0	0
RL09	1	0	1	1	1	0	0	1	0	1	0	0	1	0	0	1	1	0	0	1	0	0	1	1
RL10a	1	0	0	0	0	0	0	1	0	0	1	0	1	1	0	0	0	1	0	1	0	1	1	1
RL10b	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0
RL11	0	0	1	0	0	1	1	0	1	1	0	0	1	0	0	0	1	0	0	0	0	0	0	0
RL12	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	1	1	0	0	0
RL13a	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RL13b	0	0	1	0	1	0	0	1	0	1	0	0	1	0	0	0	0	0	0	1	1	0	0	0
RL14a	0	0	1	1	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0
RL14b	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
RL15	0	0	1	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RL17	1	0	0	0	0	0	1	1	0	0	0	0	1	0	1	1	0	0	0	1	0	0	0	0
RL18	0	0	0	0	0	0	1	0	0	0	1	0	1	1	0	1	0	0	1	0	0	1	1	1

4. Recommendations and enhancements

4.1. Enhancement options

The following enhancement options have been developed based on observation made during the walkover survey and using the results of the River Condition Assessment and underlying condition indicator scores by applying the following approach:

- The features that contribute the most to positive indicators should be retained as these represent the highest quality physical features along each subreach.
- Low scoring (<2) positive indicators that would otherwise be expected along chalk streams should be improved whilst avoiding any reduction in higher scoring positive indicators.
- All negative impacts including those contributing to negative indicators and habitat modification scores should be reduced, where feasible.

A range of options are provided under the following three main headings to help guide enhancement works and prioritise subreaches where the improvements are likely to have the greatest benefit.

- Reducing the severity and extent of artificial features
- Restoration of physical forms and features
- Renaturalising the river corridor

For each heading, options, benefits and potential constraints to delivery are provided along with a list of subreaches where such enhancements could be taken forward. A detailed description of enhancements for each subreach is provided in Appendix A. The predicted change in final condition scores should these enhancements be carried out are provided in Section 4.2. These are presented as a guide only to show how enhancements may affect the physical and habitat quality of the upper Lavant and may not consider all potential morphological changes that may occur as a result of any works. A list of assumptions used to generate the predicted condition scores is provided in Appendix B. It is recommended that expert advice from a geomorphologist and chalk stream habitat expert is sought in developing options (underpinned by evidence outlined in this report) to ensure that the maximum benefit can be derived from any implementation.

Whilst it is obvious that the continuous discharge of sewage into the river system will be having a major impact on its overall health, it is not within the remit of this report to have undertaken a detailed assessment of the level of impact, or to provide recommendations which may stop the source of pollution. It is, therefore, highly recommended that restoration of the upper Lavant is underpinned by ongoing and constructive dialogue with Southern Water over future plans and timeframes under which progress to reduce sewage pollution will progress.

It should also be noted that the following recommendations and those detailed in full in Appendix A, are provided without investigation or in-depth knowledge of localised flood risk or presence of protected species, and further information relating to the potential impact of any alterations should be sought and the relevant statutory consents obtained, prior to implementation.

1 Reducing the Severity and Extent of Artificial Features

Description:

There are a number of artificial in-channel structures and modifications along the upper Lavant that appear to be redundant (provide no benefit) or where alternative solutions would be of greater benefit to the water environment. It is therefore recommended that:

- Weirs and remnant structures that serve no function should be removed from the channel, reducing the level of impoundment, increasing connectivity and allowing natural processes to form.
- Bank reinforcements should be assessed for suitability of removal or replacement by natural approaches such as the use of woody debris or willow revetments to absorb velocity whilst protecting critical infrastructure.
- Where removal or natural replacement is not feasible, investigate opportunities for replacement with mechanically stabilised earth principles such as FlexMSE.
- Bed reinforcements should be removed where feasible
- Ford crossings to be “dressed” with gravel to relieve impoundment and reduce sediment input. Investigate options for gravel dressed geotextile entrance and exit points for ford crossings.
- Remove large trash and fencing from within the channel

Benefits:

- Removal of the effects of impoundment to form more natural hydraulic regime
- Enable the formation of a broader range of habitats, water depths and velocities
- Increase in-channel and subterranean connectivity for aquatic species to seek refuge during different flow phases and in response to impacts such as pollution
- Reduced sedimentation, cleaner gravel substrates and greater environmental resilience

Improved Condition Indicators:

C3: Natural profile extent
C4: Natural profile richness
C6: Bare sediment extent
C7: Artificial bank profile extent
C8: Reinforcement extent
C9: Reinforcement severity
D5: Artificial features
E3: Hydraulic richness
E4: Physical feature extent
E5: Physical feature richness
E7: Bed siltation
E8: Reinforcement extent
E9: Reinforcement severity
E10: Artificial feature severity

Sub-reaches:

Reinforcements:
RL03, RL05, RL09, RL10a, RL11, RL18

Weirs/structures:
RL07, RL08, RL10a

Fords:
RL02a, RL06, RL12

Trash:
RL03, RL06, RL08, RL09, RL14b, RL17

Potential Constraints

- Structures which serve a flood defence or gauging function cannot be altered
- Levels of sediment trapped behind structures may be significant and may need to be mitigated
- Asset owners wish to retain artificial features, particularly where they are part of a private dwelling or of significant heritage value

2 Restoration of Physical Forms and Features

Description:

Reinstating natural processes to the river channel will allow a greater diversity of habitat to form and help to moderate the impact of other pressures. Physical features such as woody debris, fallen trees, marginal bars/berms and natural profiles develop the morphological complexity which aquatic wildlife relies upon. It is therefore recommended that:

- Localised re-distribution of channel material is undertaken following the principles of "dig and dump" to create higher mid-channel velocity and marginal habitat niches.
- As part of tree thinning works (Option 3) trees are hinged to interact with the water column and allowing natural formation of physical features, diversity of flow and overshaded reaches sunlight to encourage wet herbaceous margins and growth of characteristic macrophytes
- Woody debris is distributed within the channel and along the banks.
- Augmentation of gravel bars, positioned within the channel to deflect flows and generate a diversity of flow regimes and velocities. This will speed up the natural reduction in channel size to match the prevailing flow regime. Setting berms at the level of Q50 Spring Flows in an alternating sequence will create highly beneficial marginal habitat through enabling variations in depth, current velocity and substrate to form.
- Reprofiling to create more varied bank profiles connected to floodplain.

Improved Condition Indicators:

C1: Riparian vegetation structure
C2: Tree feature richness
C4: Natural bank profile extent
C5: Natural bank profile richness
D1: Aquatic vegetation extent
D2: Aquatic vegetation richness
D3: Physical feature extent
D4: Physical feature richness
E1: Morphotype richness
E2: Tree feature richness
E3: Hydraulic richness
E4: Physical feature extent
E5: Physical feature richness
E6: Bed material richness
E7: Bed siltation
E12: Filamentous algae

Benefits:

- Increased sinuosity and fluvial diversity
- Improved dimensions to low flow (width to depth ratio)
- Improved connectivity with floodplain
- Increase in quality of marginal areas, providing suitable conditions for characteristic macrophytes and habitat for aquatic wildlife
- Woody features provide food and refuge during high and low flows for a range of aquatic fauna.
- Hinged trees along overshaded reaches will allow more sunlight and growth of macrophyte

Sub-reaches:

Dig & Dump/Marginal features

RL06, RL07, RL09, RL10, RL13, RL15

Woody debris

RL08, RL14

Bank reprofiling

RL02b, RL05

Potential Constraints

- Creation of in-channel features within or at close proximity to urbanised areas should consider a feasibility study to ensure works do not lead to increased localised flood risk.
- Woody features near assets (e.g. structures or residential properties) will need to be pinned to ensure movement does not cause blockages or increase flood risk.
- Access to riverbanks for machinery to undertake dig and dump and the requirement to retain all excavated material on site.

3	Renaturalising the River Corridor

Description:

Wide river corridors provide habitat and important shelter, feeding areas and migration routes for a range of species. Characteristic habitats of chalk stream catchments include a mixture of marsh with open groundwater pools, wet woodland, and open woodland with dominance of herbaceous plants due to high floodplain water tables. Currently, the majority of habitat alongside the upper Lavant is managed or urbanised/ is residential. As such, there is considerable scope to increase the condition and resilience of the River Lavant by re-naturalising the river corridor. Options include:

- Establishment of functional buffer strips and cessation/reduction in bank top mowing/grazing.
- Installing fencing to reduce poaching pressures. Fences should be erected a minimum of 10m from the bank top to allow establishment of tall fen vegetation.
- Management of homogenous lengths of nettle and bramble through appropriate cutting and removal.
- Thinning of trees/scrub in over-shaded sections, reducing to ~40% cover to provide dappled shade. Reusing material on site through hinging or distribution of woody material within the channel (Option 2).
- Planting of trees in areas where tree cover is low or is entirely absent.
- Undertaking a programme of control and eradication of INNS along the river corridor.
- Creating wetland features such as scrapes that store groundwater or capture surface/flood water.
- Enhancing existing wetland features within the floodplain

Benefits:

- Decrease risk of sediment and diffuse pollution entering the river
- Increase biodiversity and support of nature recovery through the provision of habitat
- Increase in tree feature richness and sources of large wood to river channel.
- Increased habitat heterogeneity and resilience to low flow
- Reduced risk of high river flows and flood impacts downstream

Potential Constraints

- Change in land use would require land being taken out of production and would need to be financially incentivised
- Long term management regime would be required where fencing is installed
- Floodplain works may require planning consent

Improved Condition Indicators:

B1: Vegetation structure
B2: Tree feature richness
B3: Water related features
B4: Non-native (invasive) plants
B5: Managed ground
C1: Vegetation structure
C2: Tree feature richness
C3: Natural bank profile extent
C4: Natural bank profile richness
C6: Bare sediment extent
C7: Artificial bank profile extent
C10: Non-native (invasive) plants
D1: Aquatic vegetation extent
D2: Aquatic vegetation richness
D3: Physical feature extent
D4: Physical feature richness
E1: Morphotype richness
E2: Tree feature richness
E3: Hydraulic richness
E4: Physical feature extent
E5: Physical feature richness
E7: Bed siltation
E12: Filamentous algae

Sub-reaches:

Buffer strips/fencing
RL03, RL04, RL06, RL08, RL09, RL10a, RL11, RL12, RL13, RL15, RL17, RL18

Manage nettle/bramble
RL04, RL06, RL07, RL08, RL09, RL12, RL14a, RL17

Reduce overshading
RL06, RL08, RL14b, RL18

Riparian tree planting
RL07, RL09, RL13b, RL15

Create/enhance scrapes/ponds
RL02, RL04, RL05, RL06, RL07, RL12, RL13, RL15, RL17, RL18

INNS
RL01, RL04, RL06, RL08, RL10, RL18

4.2. Predicted change in condition scores

The predicted change in condition score for each subreach has been calculated based on assumptions of likely morphological and land use changes following the enhancements set out in Appendix A and summarised in section 4.1 of this report. A table showing the set of assumptions used to develop the predicted change in condition are provided in Appendix B. The change in average positive and negative indicator scores are shown in Figure 17 with original scores provided as reference. This shows that 19 of the 20 subreaches would attain an increase in average positive indicator scores with the highest increase shown in subreach RL07. A decrease in negative scores were also attained for 19 subreaches with the largest decrease obtained in RL10a.

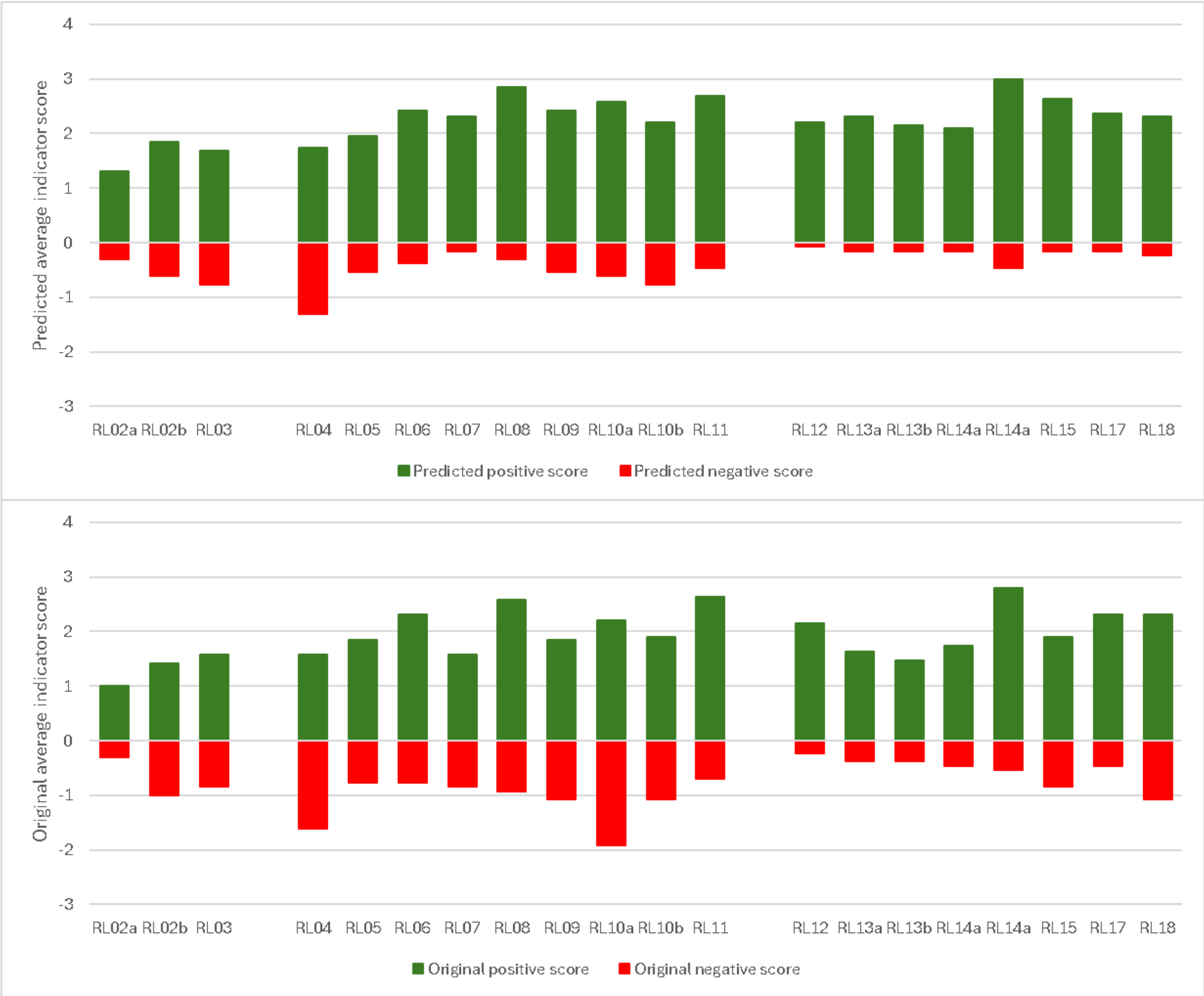

Figure 17: Charts showing the average positive and average negative indicator scores for each subreach where top shows those predicted following delivery of enhancements outlined in Section 4.1 and Appendix A and bottom shows original scores based on the MoRPH5 surveys.

The predicted condition scores and threshold values for each class are provided in Figure 18 and the change to the final condition scores are presented in Table 7. This shows that there would be an increase of one condition class for nine subreaches (one poor to fairly poor, two fairly poor to moderate, four moderate' to fairly good and two fairly good to good), two classes for two subreaches (one fairly poor to fairly good and one moderate to good) and one subreach (RL10a) could achieve an increase in three classes from poor to fairly good. A further eight subreaches showed an increase in numerical condition scores, but not condition class.

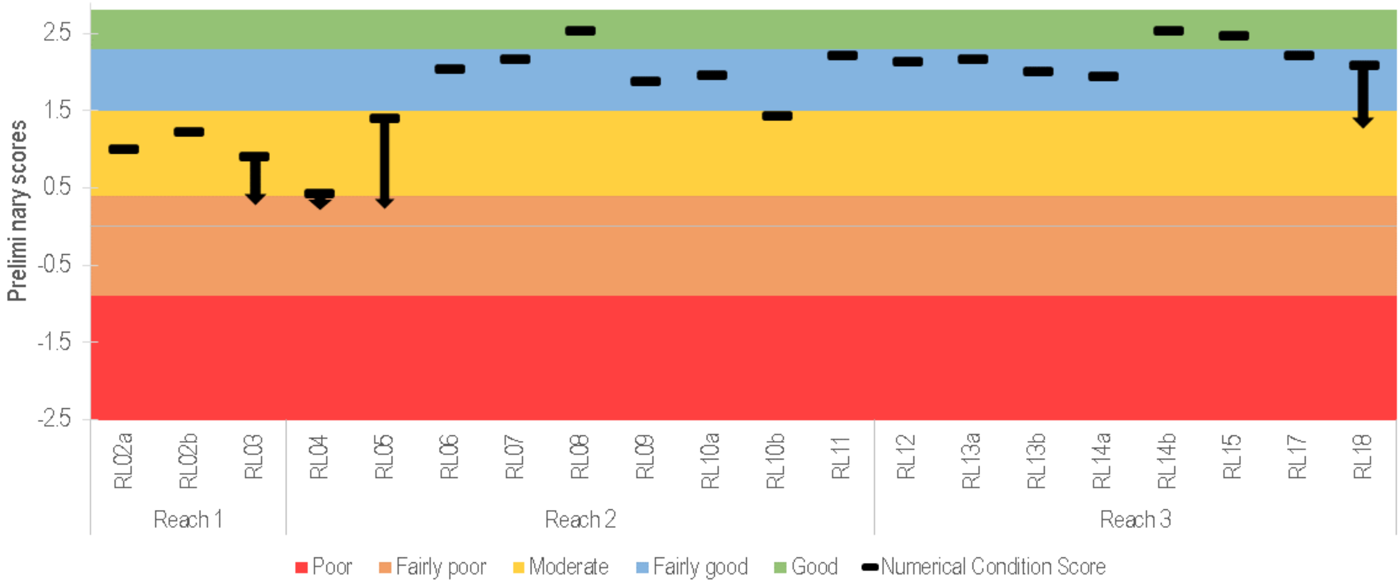

Figure 18: Chart showing the predicted change in condition scores by threshold values for each condition scores. Arrows denote the drop in condition class due to the river remaining over deep.

Table 7: showing change in condition indicator score (numerical change relative to original scores provided in parenthesis and classes following delivery of enhancements and the predicted change in condition indices that contribute towards the numerical condition score.

		Original		Predicted	
Reach	**Subreach**	**Numerical score**	**Condition class (adj)**	**Numerical score**	**Condition class (adj)**
Reach 1	RL02a	0.692	Moderate	1.008 (+ 0.32)	Moderate
	RL02b	**0.421**	**Fairly poor**	**1.227 (+ 0.81)**	**Moderate**
	RL03	0.733	Fairly poor	0.915 (+ 0.18)	Fairly poor
Reach 2	**RL04**	**-0.036**	**Poor**	**0.429 (+ 0.47)**	**Fairly poor**
	RL05	1.073	Fairly poor	1.409 (+ 0.34)	Fairly poor
	RL06	1.547	Fairly good	2.037 (+ 0.49)	Fairly good
	RL07	**0.733**	**Moderate**	**2.162 (+ 1.43)**	**Fairly good**
	RL08	**1.656**	**Fairly good**	**2.534 (+ 0.88)**	**Good**
	RL09	**0.765**	**Fairly poor**	**1.883 (+ 1.12)**	**Fairly good**
	RL10a	**0.287**	**Poor**	**1.964 (+ 1.68)**	**Fairly good**
	RL10b	0.818	Moderate	1.441 (+ 0.62)	Moderate
	RL11	1.939	Fairly good	2.223 (+ 0.28)	Fairly good
Reach 3	RL12	1.927	Fairly good	2.134 (+ 0.21)	Fairly good
	RL13a	**1.247**	**Moderate**	**2.162 (+ 0.92)**	**Fairly good**
	RL13b	**1.089**	**Moderate**	**2.004 (+ 0.92)**	**Fairly good**
	RL14a	**1.275**	**Moderate**	**1.951 (+ 0.68)**	**Fairly good**
	RL14b	**2.251**	**Fairly good**	**2.538 (+ 0.29)**	**Good**
	RL15	**1.049**	**Moderate**	**2.478 (+ 1.43)**	**Good**
	RL17	1.854	Fairly good	2.215 (+ 0.36)	Fairly good
	RL18	**1.239**	**Fairly poor**	**2.085 (+ 0.85)**	**Moderate**

This shows that there is considerable scope along the Lavant to improve the condition of subreaches by reducing the impact of human interventions and by increasing the morphological and habitat diversity through riparian and in-channel enhancements. This means that, assuming the viability of implementation and long-term management (30yrs), there are multiple sites that are ideal candidates for habitat banking and the supply of offsite biodiversity net gain, which would provide a useful funding source for enhancement works. Should this approach be taken forward, it is advised that project designs and restoration works are undertaken in collaboration with a geomorphologist and RCA accredited surveyor to ensure that the enhancement works deliver the maximum potential river units to trade.

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