Teddington Direct River Abstraction

Preliminary Environmental Information Report

Appendix 6.1 – Aquatic Ecology Baseline and Supporting Information

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Appendix 6.1 – Aquatic Ecology Baseline and Supporting Information

A.1 Introduction

A.1.1 This Appendix supports the Aquatic Ecology assessment in Chapter 6: Aquatic Ecology.

A.1.2 This appendix provides the baseline data on aquatic ecosystems, including phytoplankton, macrophytes, diatoms, macroinvertebrates, and fish populations, highlighting ecological conditions and water quality indicators across surveyed sites on the River Thames. Surveys were undertaken by Ricardo (where stated) on behalf of Thames Water to characterise the baseline for the Teddington Direct River Abstraction (TDRA) Project (hereafter referred to as 'the Project').

A.1.3 To understand the Aquatic Ecology baseline, this appendix considers data from the River Thames beyond the study area as identified in Chapter 6. This wider area captures the available public data and Project surveys and the river reaches included in this appendix are identified as below:

a. River Thames: River Thames and Thames Tideway to Southend-on-Sea.

b. Freshwater River Thames: River Thames within the study area extending from Teddington Weir to 2km upstream (or relevant upstream survey location as indicated in the figure of survey locations for each species).

c. Thames Tideway: Estuarine Thames Tideway extending from Teddington Weir to Southend-on-Sea.

d. Tidal River Thames: Thames Tideway reach from Teddington Weir to Battersea Bridge within the EIA study area.

A.2 Baseline conditions

Phytoplankton

A.2.1 Phytoplankton include photosynthesising bacteria (cyanobacteria – often referred to as blue-green algae) and photosynthesising eukaryotic protists (e.g. diatoms) and form the base of the aquatic food web. The ability to create organic carbon compounds using photosynthesis distinguishes phytoplankton from all other planktonic organisms. Plankton, including phytoplankton, cannot swim independently from a current.

A.2.2 Phytoplankton are dependent upon several key nutrients for growth, including trace metals, phosphorus, nitrates, and silicon. The response of differing communities to changing nutrient conditions is a good indicator of water quality, as nutrient availability influences community composition.

A.2.3 An increase in the number of protist communities may negatively influence water quality through increasing nutrient availability. This may fuel cyanobacterial growth, leading to further water quality deterioration.

A.2.4 Monitoring the communities within a waterbody can indicate water quality at the time of sampling and also highlight risks to water quality under changing aquatic conditions. Table A.1 shows the full list of phytoplankton site locations used to establish the baseline for the freshwater and tidal River Thames

Table A.1 List of monitoring sites included in the phytoplankton baseline

Study Area	Site Name	NGR
Freshwater River Thames	ATK6 (Surbiton)	TQ 171705 67342
	ATK5 (Walton)	TQ 11476 68777
	ATK7 (Teddington)	TQ 17147 71387
Tidal River Thames	LRUS40	TQ 1676475252
	LRUS41	TQ 1709274903
	ATK27 (RP1)	TQ 16065 72711
	ATK28 (RP2)	TQ 17106 74880

Freshwater and Tidal River Thames (Thames Water Walton Intake to Richmond Pound)

A.2.5 Baseline methodology and data for cytometry phytoplankton is presented in the Aquatic Ecology Consolidated Report[1]. Phytoplankton samples were collected from seven sites located between Walton and Richmond Pound. 1 Two of the seven sites (LRUS40 and LRUS41) were sampled once by Ricardo in October 2022 (Plate A.1). The remaining five sites were sampled by Atkins during the growing seasons between March and October, with the sampling date range varying between sites and are detailed in Table A.2 below.

A.2.6 Flow cytometry detected phytoplankton cells within a water sample and provided counts of cells per ml, splitting the counts into phytoplankton type (diatoms, cyanobacteria, cryptophytes and green algae) and (for green algae) size class; pico (cell diameter of <2µm[2]) and meso (cell diameter of 0.2 – 2mm).

A.2.7 Sites ATK27 and ATK28, located on the tidal River Thames below Teddington Weir within Richmond Pound, were sampled from May 2022 through October 2024; Sites ATK6 (Surbiton) and ATK 5 (Walton TWUL) were sampled from March 2021 through October 2022; Site ATK7 (Teddington) site was sampled from March 2021 through October 2024. Flow cytometry was used to determine the cell abundance of phytoplankton[3].

A.2.8 Across all five sites in 2024 (excluding LRUS40 and LRUS41, the data for which were analysed separately using the cell counting method), the mean

[1] Thames Water Utilities Ltd (2024) Aquatic and Estuarine Ecology Baseline Consolidated Report. Document No J698-AJ-C02B-TEDD-RP-EN-100002
[2] C.S. Reynolds, Plankton, Status and Role of, Editor(s): Simon Asher Levin, Encyclopedia of Biodiversity, Elsevier,2001, Pages 569-599, ISBN 9780122268656,https://doi.org/10.1016/B0-12-226865-2/00339-4. (https://www.sciencedirect.com/science/article/pii/B0122268652003394)
[3] Flow cytometry method: DOI: 10.1039/c3em00657c

majority of the phytoplankton community was represented by green (pico) phytoplankton (cells <2µm in diameter) which represented the highest mean counts at each of the sampling site.

A.2.9 The remaining phytoplankton from highest to the lowest mean abundance at the majority of the sites were the green (meso) phytoplankton, cyanobacteria, the diatoms and finally the cryptophytes recording the lowest abundance at each site (Plate A.1). The exception to this was Site ATK6 (Surbiton) from highest to lowest mean abundance were the green-meso phytoplankton, diatoms, cyanobacteria and finally the cryptophytes.

A.2.10 Site ATK5 (Walton) recorded the highest mean count of all phytoplankton categories. The lowest counts for all categories of phytoplankton were recorded at Site ATK28 (Richmond Pound 2), with the exception of diatoms. The lowest count was recorded at Site ATK27 (Richmond Pound 1) (Table A.2).

Table A.2 Average, standard deviation (SD), minimum and maximum value for phytoplankton across five sites from 2024. The highest abundance of each algal category is highlighted in red.

Site	Number of datapoints	Data date range	NGR	Stat	Green (pico) (abundance, cells ml^{-1})	Green (meso) (abundance, cells ml^{-1})	Cyanobacteria (abundance, cells ml^{-1})	Diatoms (abundance, cells ml^{-1})	Cryptophytes (abundance, cells ml^{-1})
ATK 27 (RP1)	91	May 2022 – Oct 2024	TQ 16065 72711	Mean	19223.71	3195.50	2205.86	**411.05**	358.77
				SD	19525.50	5530.78	4289.79	548.11	276.48
				Min	1337.79	452.63	136.47	47.10	24.37
				max	79487.67	44849.10	34354.50	4462.29	1749.35
ATK28 (RP2)	91	May 2022 – Oct 2024	TQ 17106 74880	Mean	**18372.75**	**2878.81**	**2171.52**	528.11	**308.09**
				SD	19675.58	4787.13	4054.30	714.03	187.65
				Min	1423.28	296.04	151.09	29.81	9.75
				max	80120.13	38940.78	27310.01	5855.09	1077.75
ATK6 (Surbiton)	55	Mar 2021 – Oct 2022	TQ 171705 67342	Mean	33416.82	7897.59	2937.18	3945.02	478.36
				SD	27617.92	11771.99	2948.09	12372.74	307.75
				Min	3982.86	423.88	203.09	53.83	50.77
				max	119494.54	70811.41	11175.64	71369.92	1454.90
ATK5 (Walton)	54	Mar 2021 – Oct 2022	TQ 11476 68777	Mean	**57367.37**	**10005.64**	**6122.17**	**4493.11**	**605.65**
				SD	57643.08	15558.61	7624.45	13184.28	486.85
				Min	3678.22	201.85	259.51	20.18	60.55
				max	273584.54	94245.97	26733.80	72859.26	2905.37
ATK7 (Teddington)	124	Mar 2021 – Oct 2024	TQ 17147 71387	Mean	23640.60	5806.91	2194.46	2174.67	401.43
				SD	26709.90	11148.32	3891.94	8848.16	472.28
				Min	67.28	6.73	6.73	0.00	0.00
				max	180643.55	91741.17	31838.13	75696.90	3691.50

Key: Blue text – lowest mean count; Red text – highest mean count

A.2.11 The occurrence of organisms listed in Table A.2 was analysed to help determine seasonal growth patterns, this analysis excluded Sites LRUS 40 and LRUS 41 due to the single-season sampling nature of the dataset for these sites.

A.2.12 The LRUS40 and LRUS41 sites recorded a total count of 42,520 cells ml^{-1} and 23,583 cells/ml, respectively.

Relative abundance

A.2.13 The water quality spot samples collected from each of the five sites in 2024 were also analysed for relative abundance (Table A.3).

Table A.3 Relative abundance of phytoplankton. The highest relative abundance for each algal category is highlighted in red.

Site	Number of datapoints	Data date range	NGR	Stat	Greenpico (abundance, cells/ml)	Greenmeso (abundance, cells/ml)	Crypto-phytes (abundance, cells/ml)	Diatoms (abundance, cells/ml)	Cyano-bacteria (abundance, cells/ml)
ATK 27 (RP1)	91	May 2022 – Oct 2024	TQ 16065 72711	Average	0.69	0.15	0.03	0.03	0.10
				SD	0.16	0.12	0.02	0.04	0.08
				Min	0.39	0.02	0.00	0.00	0.01
				max	0.95	0.57	0.09	0.18	0.42
ATK28 (RP2)	91	May 2022 – Oct 2024	TQ 17106 74880	Average	0.69	0.15	0.03	0.04	0.09
				SD	0.16	0.12	0.02	0.04	0.08
				Min	0.29	0.02	0.00	0.00	0.01
				max	0.95	0.64	0.10	0.22	0.44
ATK5 (Walton)	55	Mar 2021 – Oct 2022	TQ 11476 68777	Average	0.71	0.14	0.01	0.07	0.07
				SD	0.24	0.16	0.01	0.14	0.07
				Min	0.07	0.01	0.00	0.00	0.01
				max	0.95	0.77	0.05	0.62	0.31
ATK6 (Surbiton)	54	Mar 2021 – Oct 2022	TQ 171705 67342	Average	0.71	0.15	0.01	0.07	0.07
				SD	0.22	0.14	0.01	0.14	0.05
				Min	0.07	0.02	0.00	0.00	0.01
				max	0.94	0.73	0.03	0.66	0.24
ATK7 (Teddington)	124	Mar 2021 – Oct 2024	TQ 17147 71387	Average	0.68	0.17	0.02	0.06	0.08
				SD	0.20	0.13	0.02	0.10	0.08
				Min	0.06	0.02	0.00	0.00	0.01
				max	0.96	0.75	0.15	0.69	0.54

Key: Red text – highest relative abundance

A.2.14 The green (pico) phytoplankton group (data range varying between March 2021 to October 2024, with the number of samples and sampling date range being site-dependant), recorded the highest relative abundance at each site, resulting in domination over the other phytoplankton. The highest green (pico) phytoplankton abundance was observed at Site ATK6 (Table A.3).

A.2.15 The phytoplankton with the least abundance were cryptophytes which contributed less than 5% towards the overall phytoplanktonic samples.

Diatoms

A.2.16 Diatoms are eukaryotic organisms which form colonies of individuals varying in shape and may be either planktonic (pelagic) or benthic (i.e. grow within/on the substrate). This section only considers the planktonic communities. Diatoms can exhibit a period of rapid growth followed by a period of rapid cell death in response to nutrient availability, but diatoms also require a high level of silicon to support their growth (a trait unique to this group) due to their silica shells known as frustules. Therefore, a decrease in silicon to below concentrations essential for growth, more specifically, to build cell walls, results in a rapid decrease in cell numbers. In this way, availability of silicon, rather than phosphorus or nitrogen (as typical for other algal groups), can become a limiting factor for this group.

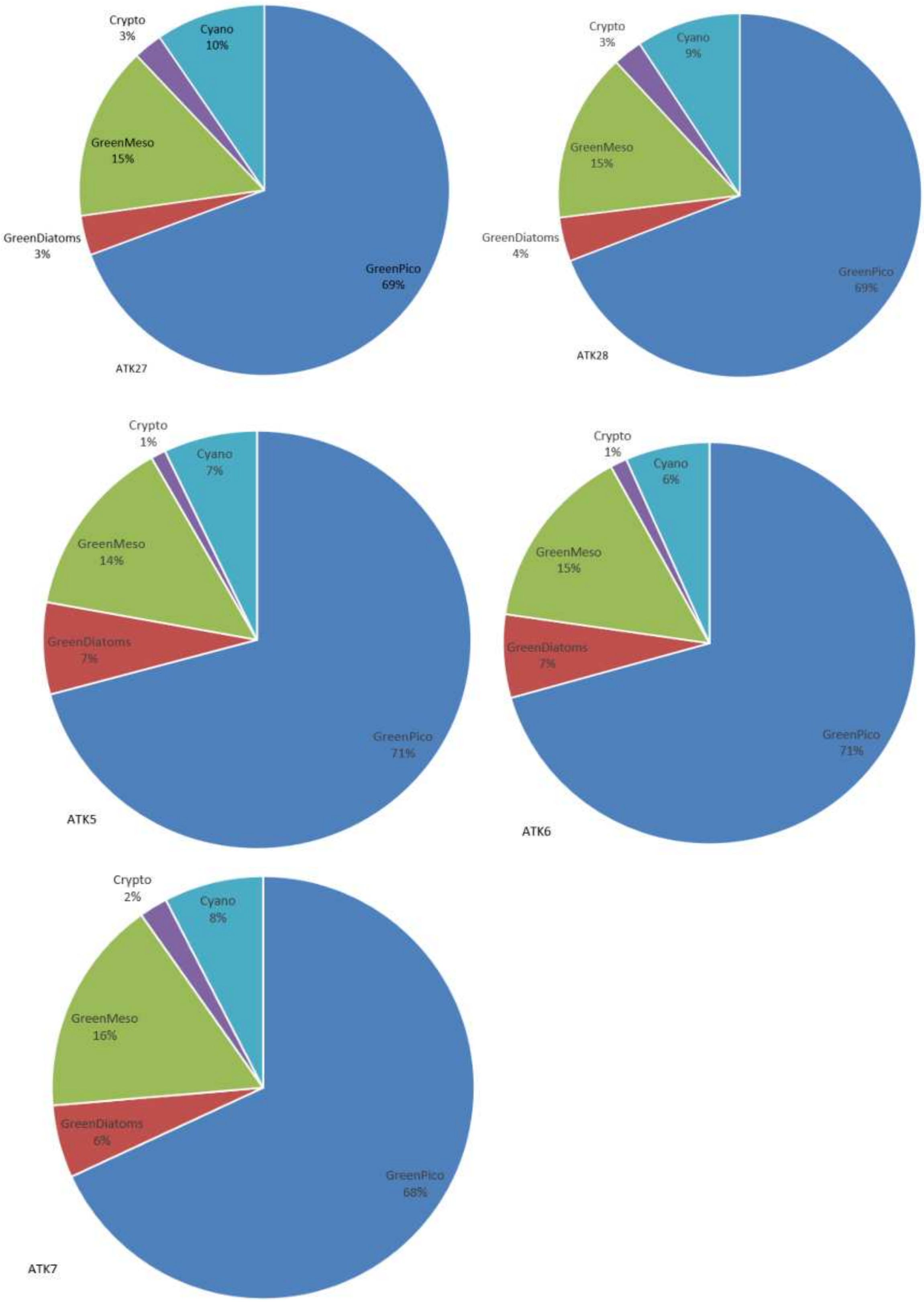
A.2.17 The occurrence of diatom blooms varied between sites; the diatom growth recorded at Site ATK27 observed a spring bloom during each sampling year, followed by smaller peaks in abundance during late summer. However, the initial sampling season of spring of 2022 recorded a higher abundance of diatoms (4,462 cells ml^{-1}) relative to the spring of the following two years (2023 and 2024) of sampling at this site (1,086 cells ml^{-1} and 1,224 cells ml^{-1} respectively).

A.2.18 The occurrence of diatom growth at Site ATK28 was very similar to that at Site ATK27, with a relatively high initial spring peak (5,855 cells ml^{-1} during 2022). However, unlike the growth patterns at Site ATK27, a higher frequency of an increase in diatom abundance through the summer period was also observed.

A.2.19 Site ATK5 also recorded a peak in diatom cell count during the first year of sampling (spring 2021; 72,859 cells ml^{-1}), with no further peaks recorded over the sampling period.

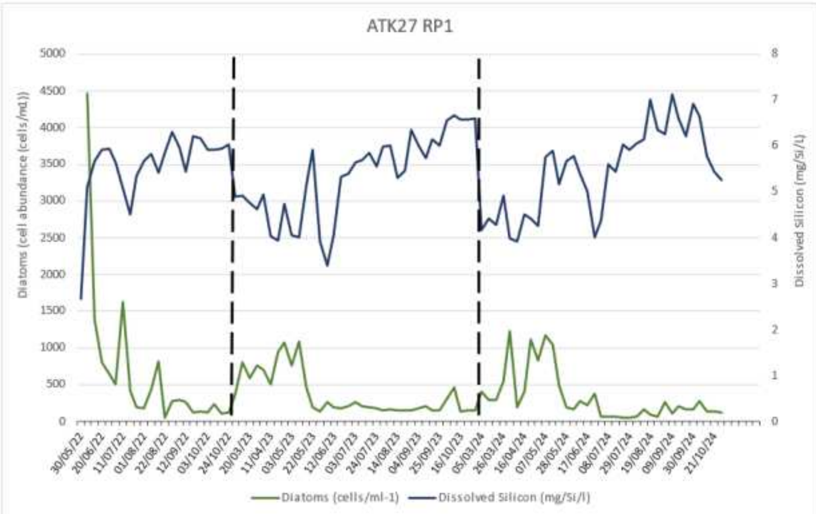
A.2.20 The two growing seasons sampled at Site ATK6 recorded one peak (of 71,369 cells ml^{-1} during May 2022) followed by a lower peak cell count the following sampling month (2,936 cells ml^{-1}, June 2022). Similarly to that at Site ATK6, a peak in cell count was observed during the spring of 2021 at Site ATK7 (Teddington) (75,69 cells ml^{-1}, March 2021). Values for Sites ATK5, ATK6 and ATK7 beyond spring 2021 remained below 5,000 cells/ml for the remainder of the sampling period.

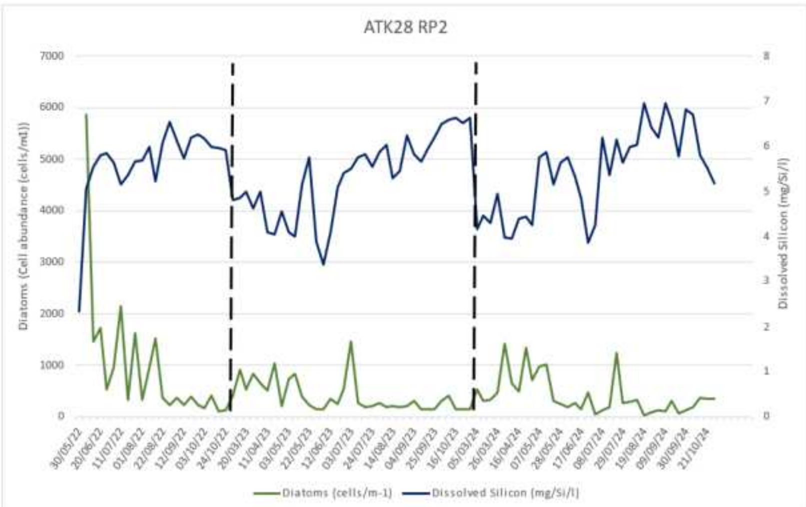
Plate A.1 Relative abundance of phytoplankton at five sites

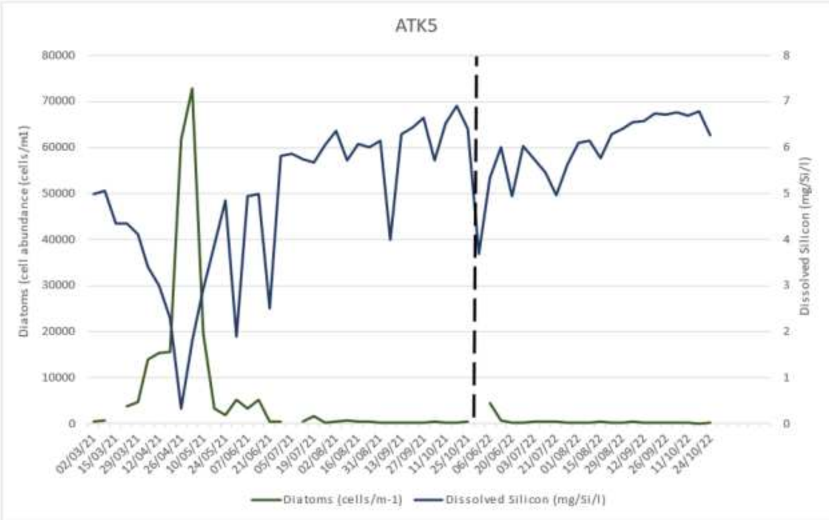


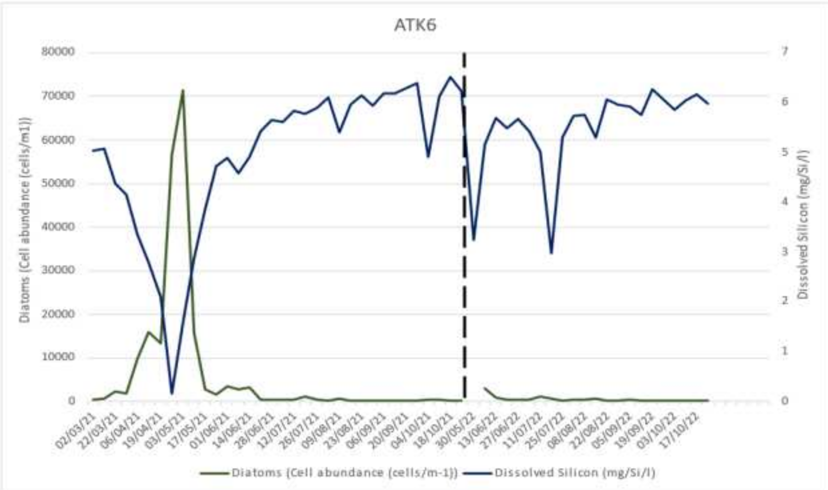
A.2.21 An inverse relationship was identified between diatom cell counts and silicon concentrations at each of the five sampling sites (Plate A.2), indicating a limiting availability of silicon for diatom growth. An increase in diatom numbers coincided with a decrease in silicon concentration, suggesting that the assimilation of silicon into the cell during growth is the likely reason for the decrease in silicon concentrations. Similarly, cell death and lysis (disintegration (rupture) of cell wall) will likely have been the cause of an increase in silicon as blooms subside.

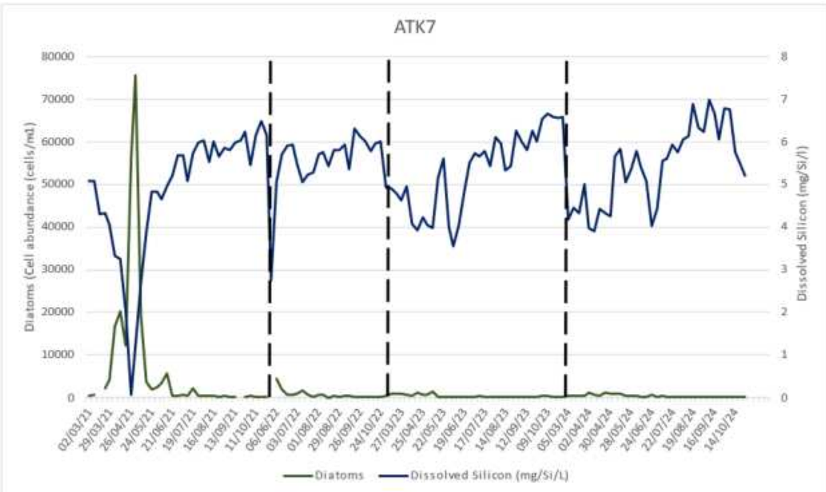
Plate A.2 The growth and concentrations of diatoms and silicon over the growing season at each of the five sites. Graphs show diatom (cell abundance (cells/m1)) plotted in green) and dissolved silicon (mg/Si/L) (plotted in blue) between 2021 and 2024 for each baseline site. Please note the variation in axis ranges.





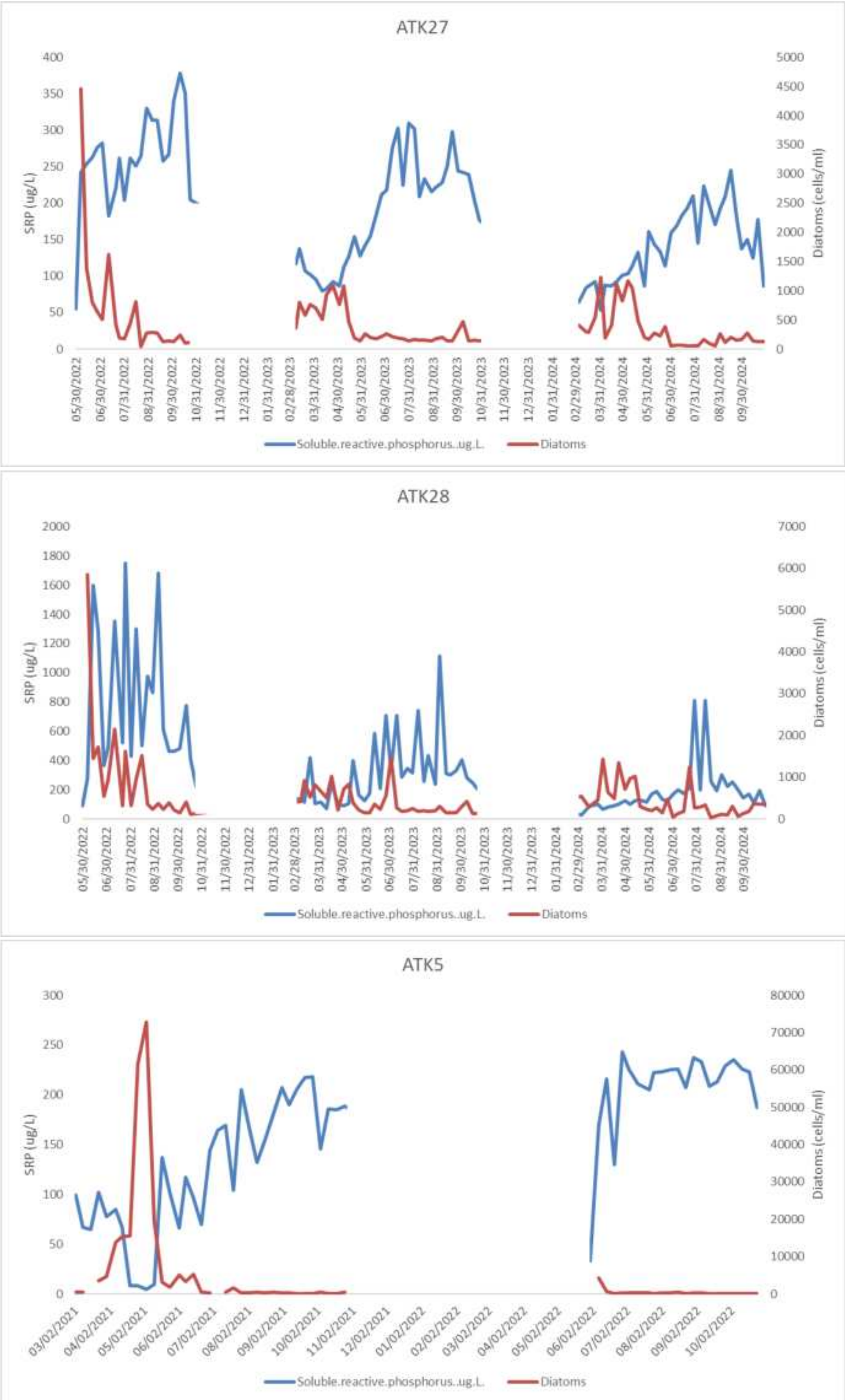


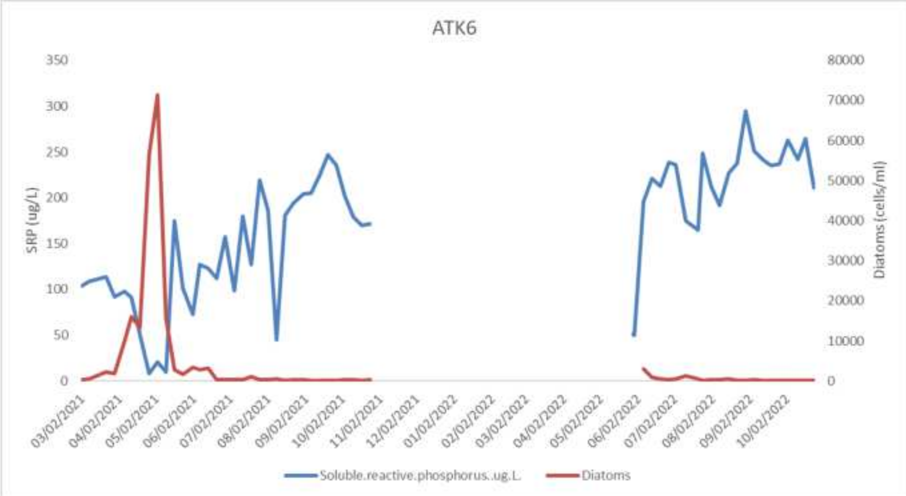


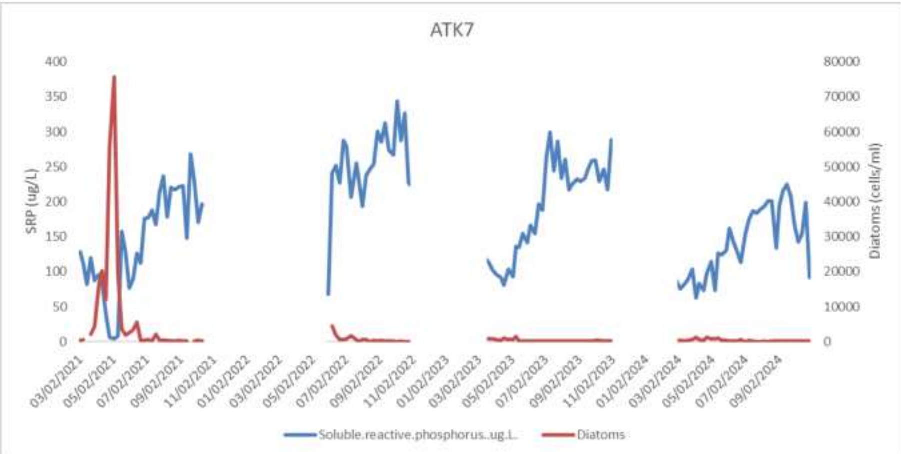


A.2.22 Diatom abundance is unlikely to be limited by SRP concentrations alone. Despite raised SRP concentrations at the sites, diatom abundance did not increase to the same extent as recorded during the spring of 2022 (Plate A.4). The lack of a growth response to raised SRP concentrations to the extent recorded during the spring of 2022 indicate the influence of other variables upon the abundance of diatoms at these sites.

Plate A.3 The growth and concentrations of diatoms and SRP (ug/L) over the growing season at each of the five sites. Graphs show diatom (cell abundance (cells/ml) and SRP (ug/L) between 2021 and 2024 for each baseline site.







A.2.23 The highest peak diatom abundance observed during the first sampling occasion at each site may represent changes to the sampling/analytical methods or indicate water quality changes not captured before the sampling began.

Green (pico and meso) phytoplankton

A.2.24 The green (pico) phytoplankton are distinguished from the green (meso) phytoplankton as having a cellular diameter of <2μm[4]. They often dominate in oligotrophic environments and make a significant contribution towards primary productivity relative to other phytoplanktonic communities. Green (meso) phytoplankton are larger than picophytoplankton (0.2 – 2mm) but retain the same photosynthetic abilities.

A.2.25 Overall, the green (pico) phytoplankton were more abundant than the green (meso) phytoplankton at each site over the sampling period; however, an occasional spike in the abundance of green (meso) phytoplankton was recorded over the summer period. A seasonal growth pattern was observed for both the green (pico) and green (meso) phytoplankton at all sites. Typically, the green (pico) phytoplankton recorded peaks in abundance during the mid-to-late

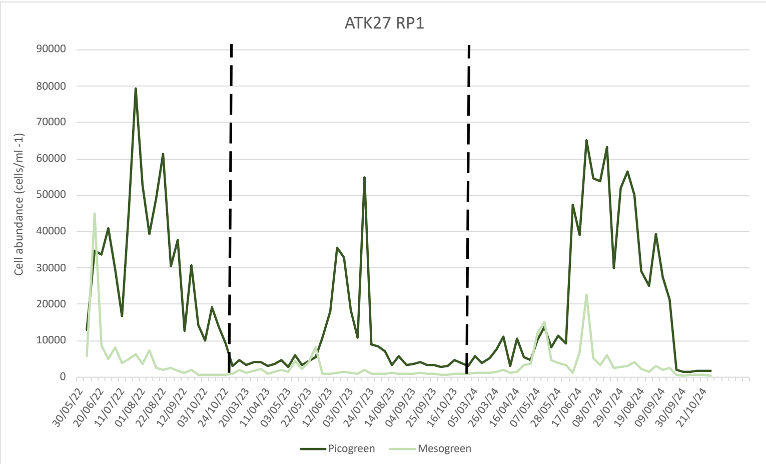
[4] C.S. Reynolds, Plankton, Status and Role of, Editor(s): Simon Asher Levin, Encyclopaedia of Biodiversity, Elsevier,2001, Pages 569-599, ISBN 9780122268656,https://doi.org/10.1016/B0-12-226865-2/00339-4. (https://www.sciencedirect.com/science/article/pii/B0122268652003394)

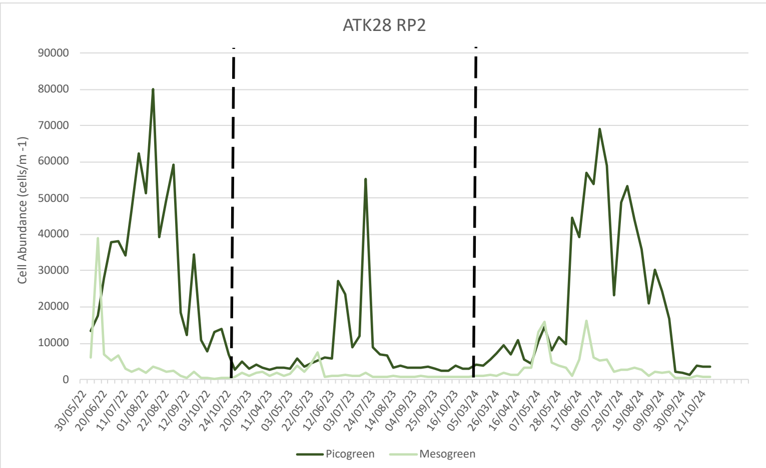
summer at all five sites; conversely, each sampling site recorded a springtime peak in abundance of green (meso) phytoplankton.

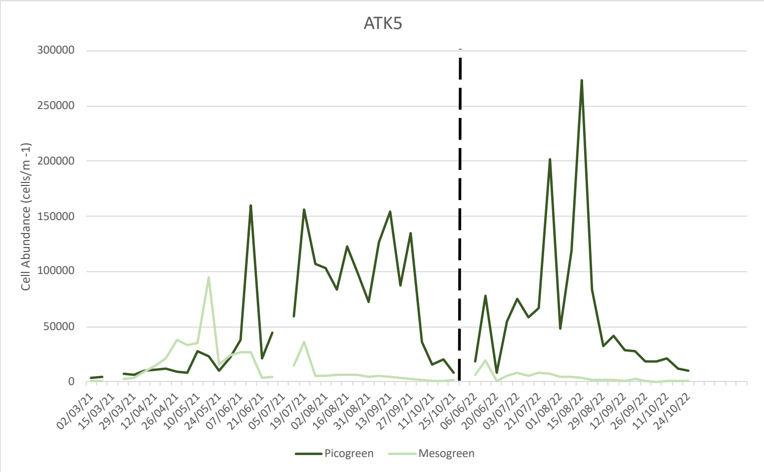
A.2.26 Sites ATK27 and ATK28 recorded a lower mean abundance of green (pico) phytoplankton (19,224 cells ml^{-1} and 18,373 cells ml^{-1}, respectively) and green (meso) phytoplankton (3,195 cells ml^{-1} and 2,879 cells ml^{-1}, respectively), relative to that at Sites ATK5, ATK6 and ATK7. The green (pico) phytoplankton abundance at the latter three sites recorded a mean cell abundance of 57,367 cells ml^{-1}, 33,416 cells ml^{-1} and 23,640 cells $ml^{-1,}$ respectively.

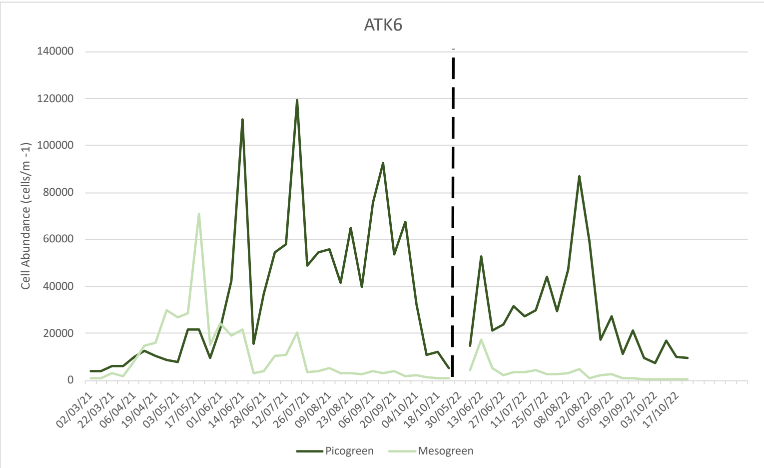
A.2.27 Sites ATK27 and ATK28 also recorded lower peak values relative to Sites ATK5, ATK6 and ATK7, with peak green (pico) phytoplankton abundance reaching 79,488 cells ml-1 (ATK27) and an abundance of 80,120 cells ml-1 (ATK28). Similarly, peak green (meso) phytoplankton reached 44,849 cells/ml at Site ATK27 and 38,941 cells/ml at Site ATK28 (Plate A.4).

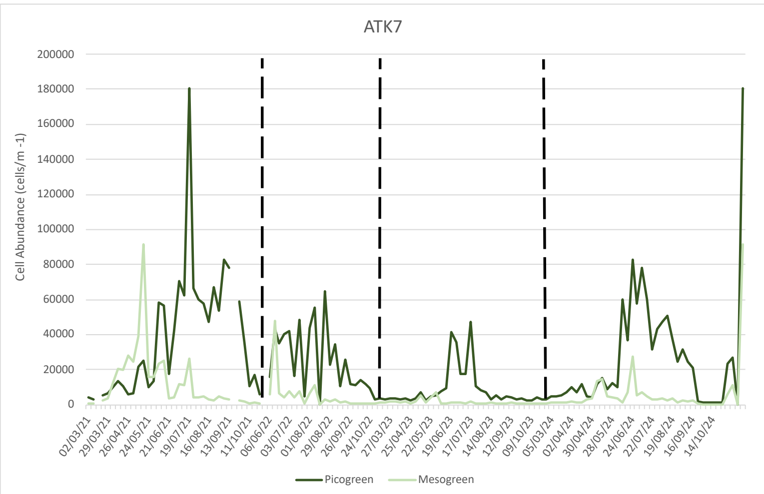
Plate A.4 Growth patterns of green (pico) and green (meso) phytoplankton over the growing season at each of the five sites. Graphs show cell abundance (cells/m-1) for picogreen (plotted in dark green) and mesogreen (plotted in light green) between 2021 and 2024 for each baseline site. Please note variations in axes ranges.











A.2.28 The peak counts of pico- and green (meso) phytoplankton at Sites ATK5, ATK6 and ATK7 reached concentrations of 273,585 cells ml^{-1} at Site ATK5, 119,495 cells ml^{-1} at Site ATK6, and 180,644 cells ml^{-1} at Site ATK7. The data indicates Site ATK5 is the most favourable to phytoplankton growth when compared to the other sites sampled. Sites ATK5, ATK6 and ATK7 may be predisposed to favour the growth of both the pico- and green (meso) phytoplankton and are more likely to experience algal blooms relative to Sites ATK27 and ATK28.

Cyanobacteria

A.2.29 Cyanobacteria are more abundant in lakes and reservoirs relative to riverine environments. However, their presence can indicate poor or deteriorating water quality. Some strains of cyanobacteria are capable of producing and releasing metabolites detrimental to final water quality when the freshwater is abstracted for treatment for potable water. In addition, some strains of cyanobacteria produce toxins during the growing season, which may ultimately affect the health of animals drinking from the river.

A.2.30 Cyanobacteria require key nutrients for growth, primarily nitrogen and phosphorus. However, aquatic environments low in such nutrients (oligotrophic environments) also pose a risk to cyanobacterial blooms; cyanobacterial response to such conditions may result in a cyanobacterial bloom and toxin/taste and odour metabolite production.

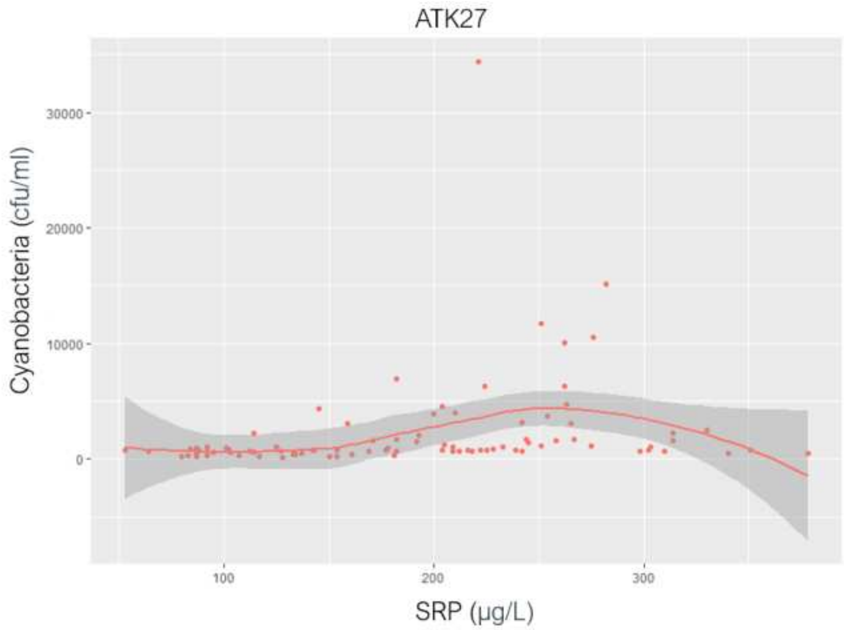
A.2.31 Cyanobacteria can thrive in conditions unfavourable to algal growth due to several evolutionary adaptations. Such conditions include low nitrogen environments; cyanobacteria are able to 'fix nitrogen'. The process of nitrogen fixation converts molecular dinitrogen (N_2) to ammonia (NH_3), resulting in an increase in nitrogen availability for the cyanobacteria and other phytoplankton.

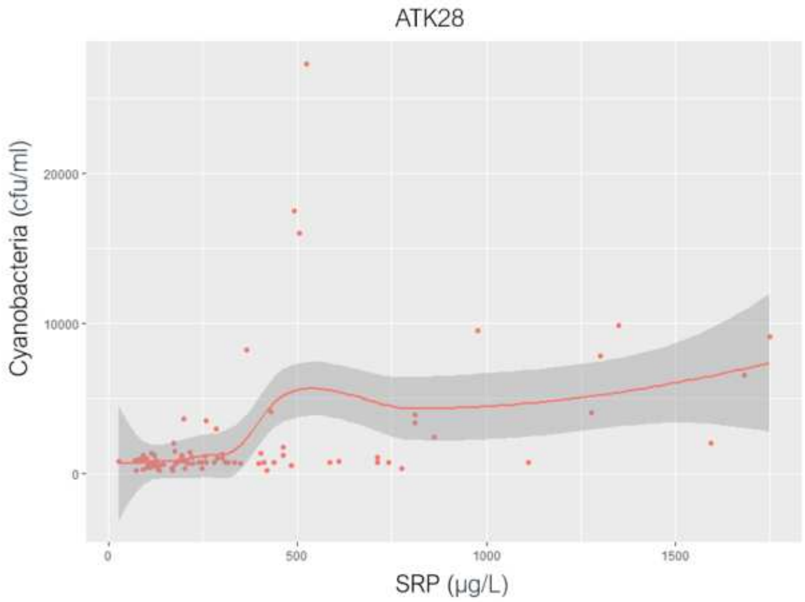
A.2.32 An increase in ammonium (NH4+) concentrations increases the risk of a more rapid cyanobacterial bloom and the production of undesired metabolites.

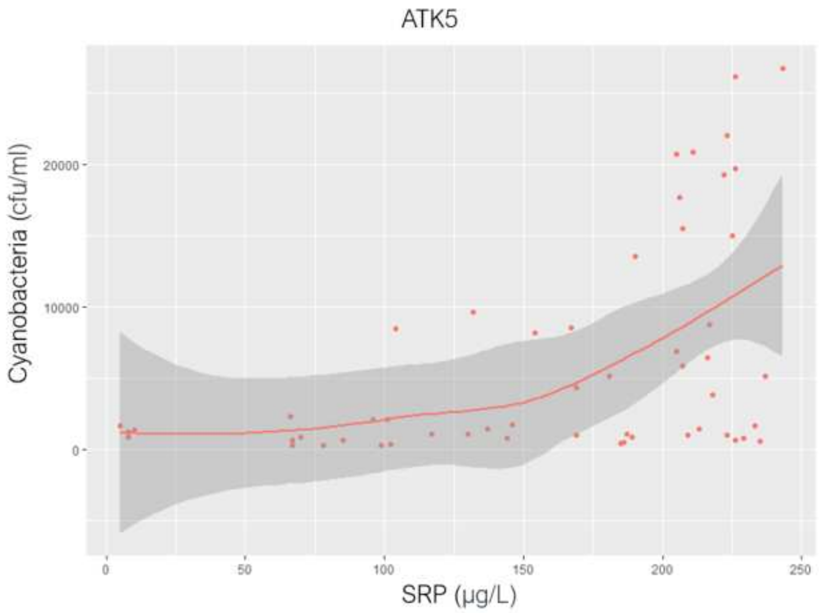
A.2.33 The highest mean count of cyanobacteria was recorded at Site ATK5 (6,122 cells ml^{-1}), with counts at the remaining sites recording values between 2,000 and 3,000 cells ml^{-1} . Seasonal peaks were identified at Site ATK5, with the peak abundance increasing at each sampling season.

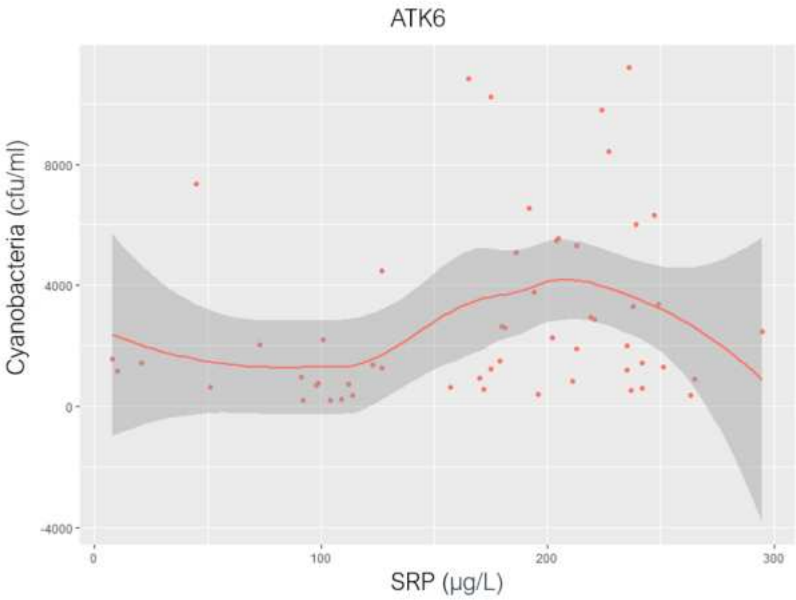
A.2.34 Phosphorus is typically the limiting nutrient in freshwater ecosystems, whereas nitrogen tends to be the limiting factor in coastal marine environments. A positive relationship was evident between cyanobacterial abundance and Soluble Reactive Phosphorus (SRP) concentrations at each of the sites (Plate A.5). However, some sites demonstrated a decrease in cyanobacterial counts as the SRP concentration increased, suggesting a diminishing key nutrient or returning unfavourable growing conditions. SRP concentrations may have increased as a consequence of cyanobacterial death, during which cell lysis releases cellular constituents, including stored phosphorus, into the water.

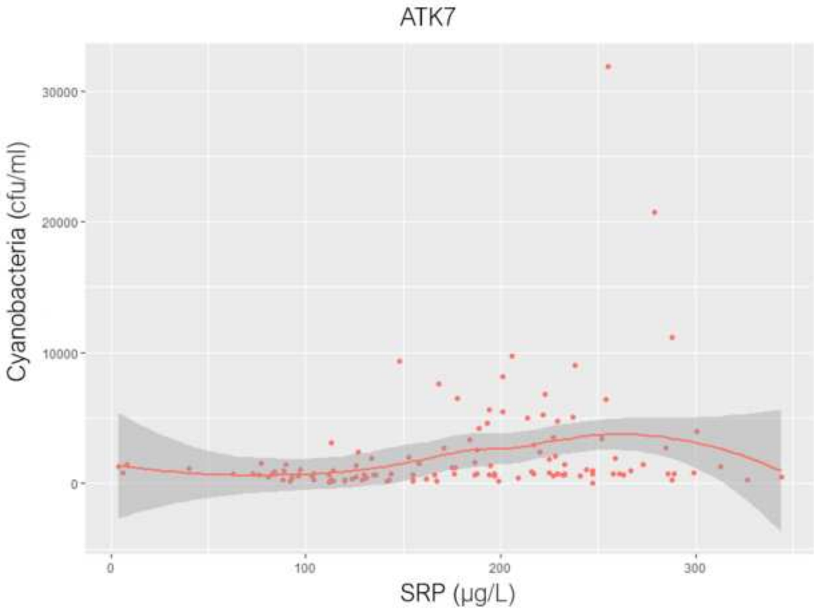
Plate A.5 Relationship between SRP concentrations with cyanobacterial cell counts demonstrating the trend within a 0.95 confidence limit






ATK5
Cyanobacteria (cfu/ml)
20000
10000
0
0
50
100
150
200
250
SRP (µg/L)


ATK6
Cyanobacteria (cfu/ml)
8000
4000
0
-4000
0
100
200
300
SRP (µg/L)



A.2.35 The cyanobacterial relationship with ammonium demonstrated an increase in cell counts as the concentration of ammonium increased; however, the non-linear relationship between cyanobacterial growth and ammonium concentrations suggests the effect of other conditions upon cyanobacterial growth alongside ammonium assimilation.

Cryptophytes

A.2.36 Cryptophytes are a type of algae that are generally found in water of good quality[5]. They are important primary producers in freshwater environments and can catch and eat prey (e.g., bacteria). They also use photosynthesis to create cellular energy.

A.2.37 The mean cryptophyte cell counts remained below 650 cells ml^{-1} and above 300 cells ml^{-1} at all sites. The highest cell count was isolated at Site ATK5 (606 cells ml^{-1}).

A.2.38 The data suggested Site ATK5 may be most likely to experience cryptophyte blooms. The risk of such blooms varies under changing conditions, e.g. an increase in water temperature may increase phytoplankton abundance, with changes made to the community structure in response to such water quality changes.

Chlorophyll-a

A.2.39 Chlorophyll-a (chl-a) is used in oxygenic photosynthesis and is an index of phytoplankton biomass but does not differentiate between species. It is essential for photosynthesis in cyanobacteria and algae; all organisms

[5] Luo W, Bock C, Li HR, et al. Molecular and microscopic diversity of planktonic eukaryotes in the oligotrophic Lake Stechlin (Germany). Hydrobiologia. 2011;661:133-143

performing photosynthesis contain chl-a[6]. An increase in chl-a indicates an increase in phytoplanktonic cell numbers.

A.2.40 The chl-a peak concentrations varied at each site, with the highest overall spring peak concentrations recorded at Sites ATK5, ATK6 and ATK7 (>200 µg L^{-1}). Subsequent peaks were lower at these sites during the remainder of the sampling period, with peaks remaining below 50 µg L^{-1}. In contrast, the chl-a concentrations remained below 50 µg L^{-1} over the sampling period at both Site ATK27 and ATK28.

A.2.41 Mean chl-a abundance was lower at Site ATK26 (5.51 µg L^{-1}) and ATK27 (5.87 µg L^{-1}) relative to Sites ATK5 (17.66 µg L^{-1}), ATK6 (16.86 µg L^{-1}) and ATK7 (10.32 µg L^{-1}).

A.2.42 The chl-a concentrations demonstrated a seasonal pattern, but the peaks did not mirror the peak water temperature values as would typically be expected; instead, peaks and troughs in chl-a concentrations were frequently recorded throughout the growing season, suggesting the seasonal succession of different groups, influences of a nutrient or micronutrient becoming limiting as a consequence of a higher rate of assimilation, or suboptimal growing conditions. Periods of such suboptimal growing conditions and lower cell numbers may then be followed by an increase in cell numbers in response to an increased availability of nutrients (as a result of the release of nutrients during cell death) or a return to favourable conditions.

A.2.43 Sites ATK5, ATK6 and ATK7 may be more favourable to phytoplanktonic establishment as suggested by their higher mean abundance relative to other sites. Changes to water quality, such as an increase in temperature, may increase the risk of an increase in biomass at all locations.

Temporal analysis

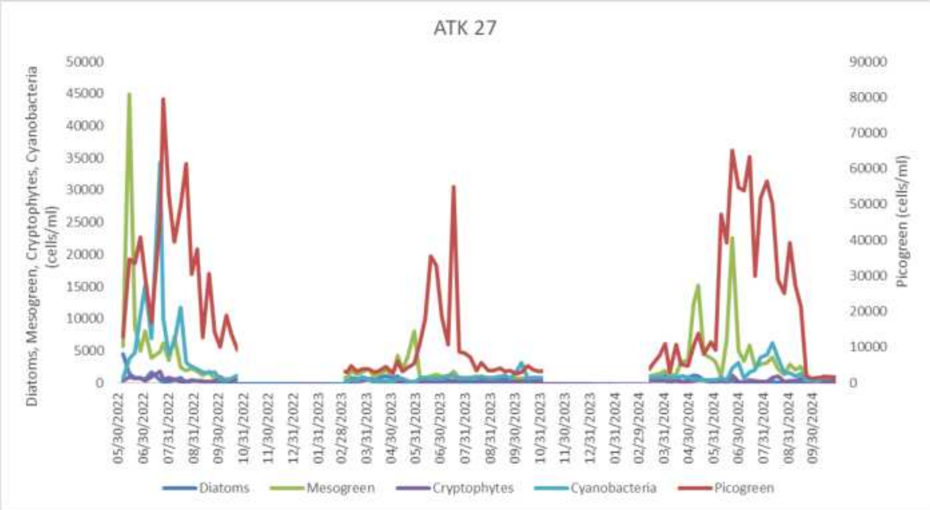
A.2.44 Phytoplankton display individual growing characteristics resulting in overlapping growing periods over the spring/summer seasons. However, all typically increase in cell numbers over the warmer periods in response to an increased metabolic rate and availability of nutrients.

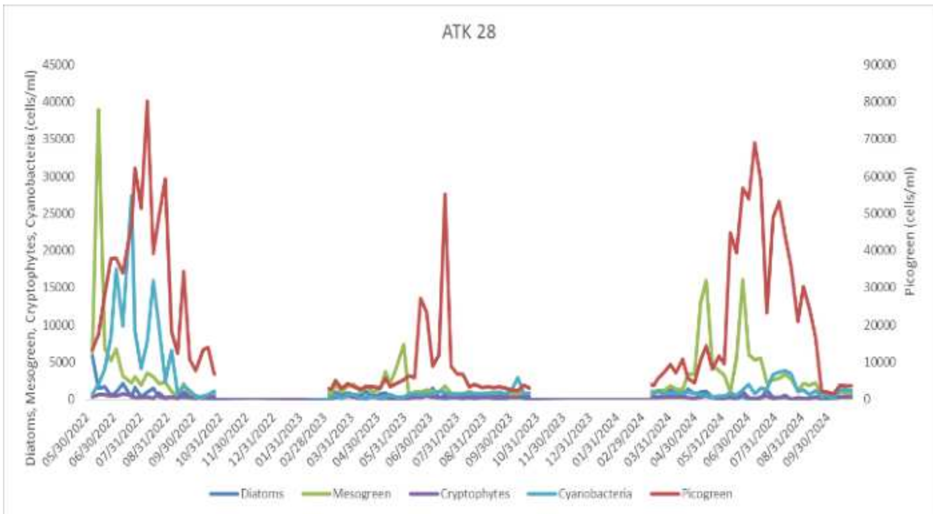
A.2.45 Nutrient availability is determined by numerous factors including meteorological factors and microbial metabolic activity, the latter which increases during warmer conditions.

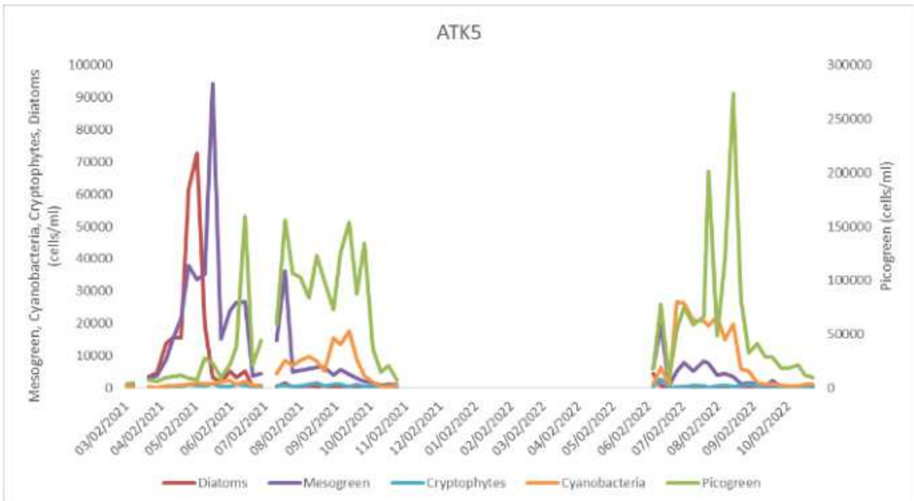
A.2.46 Seasonal growth patterns of the phytoplankton in response to increased water temperature and nutrients was more evident for the Cyanobacteria, Meso-green and Pico-green algae (Plate A.1) than for the Diatoms and Cryptophytes. Growth patterns demonstrated by the Cryptophytes and Diatoms did not display the characteristic bell-shaped curve of the other phytoplankton groups (Plate A.6).

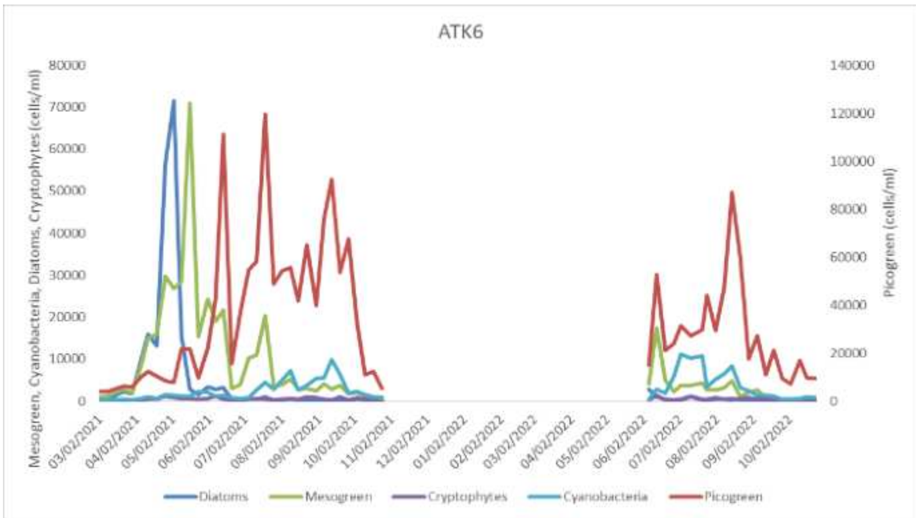
[6] Guorui Jin, Molamma P. Prabhakaran, Susan Liao, Seeram Ramakrishna, Photosensitive materials and potential of photocurrent mediated tissue regeneration, Journal of Photochemistry and Photobiology B: Biology, Volume 102, Issue 2, 2011, Pages 93-101, ISSN 1011-1344, https://doi.org/10.1016/j.jphotobiol.2010.09.010.

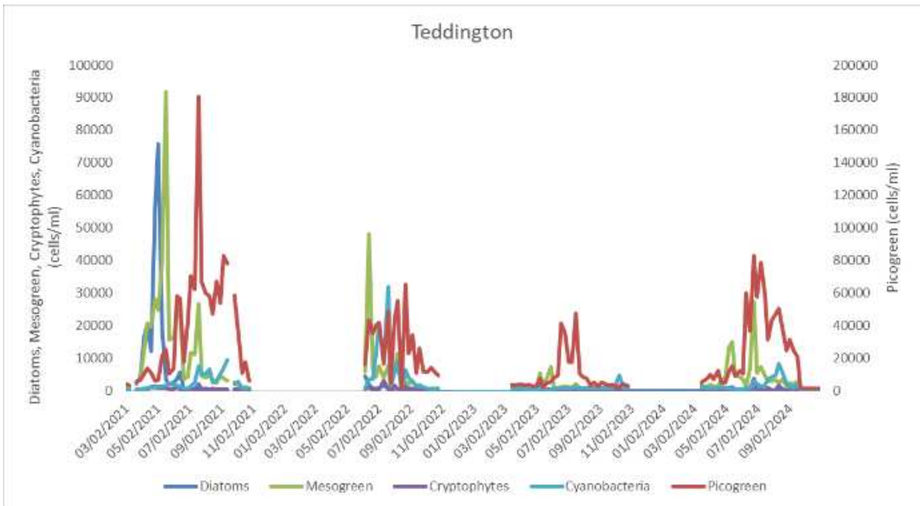
Plate A.6 Phytoplankton seasonal growth patterns at each site: ATK 27 (top left); ATK 28 (top right); ATK 5 (middle left); ATK 6 (middle right); Teddington (bottom left).







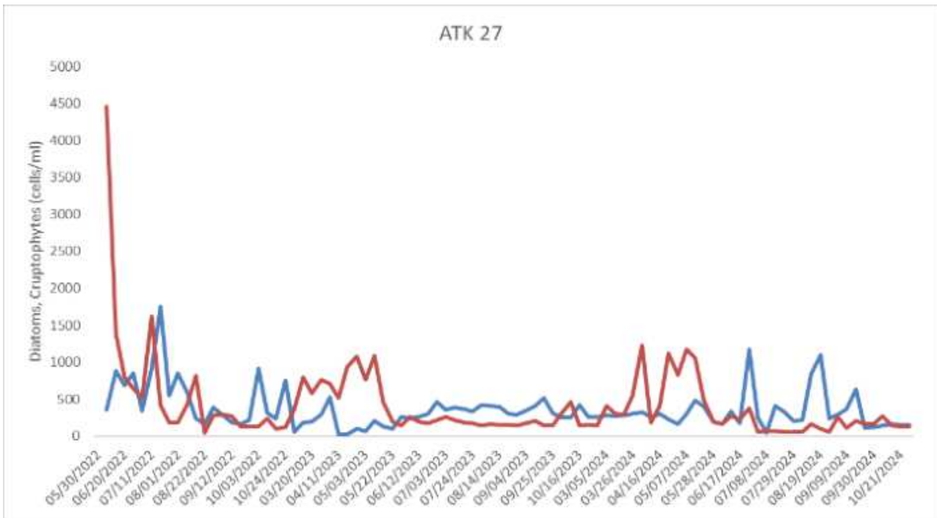


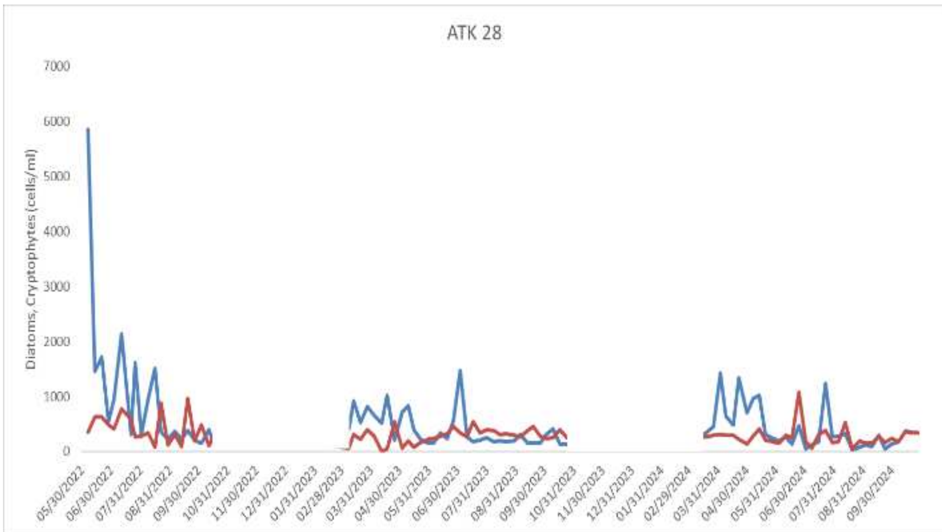


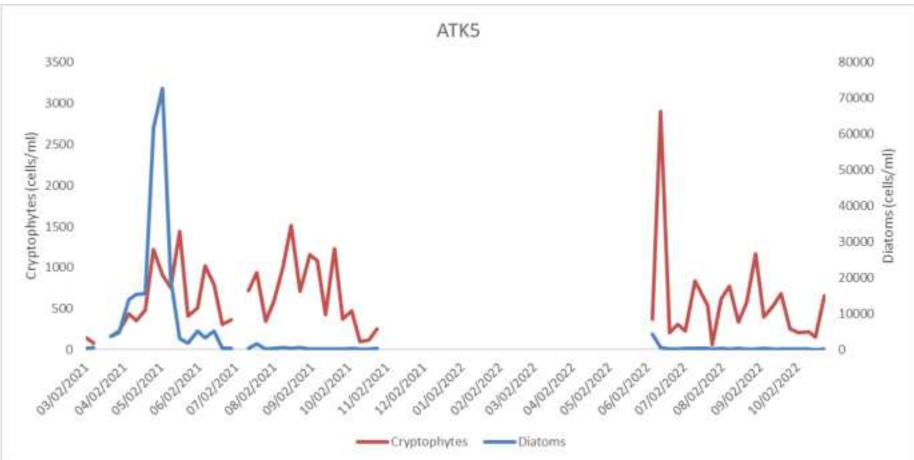
A.2.47 The growth patterns demonstrated by the phytoplankton and Diatoms differed from that of the remaining phytoplankton by demonstrating a growth pattern devoid of large seasonal peaks, except for an initial growth peak recorded during spring of 2022.

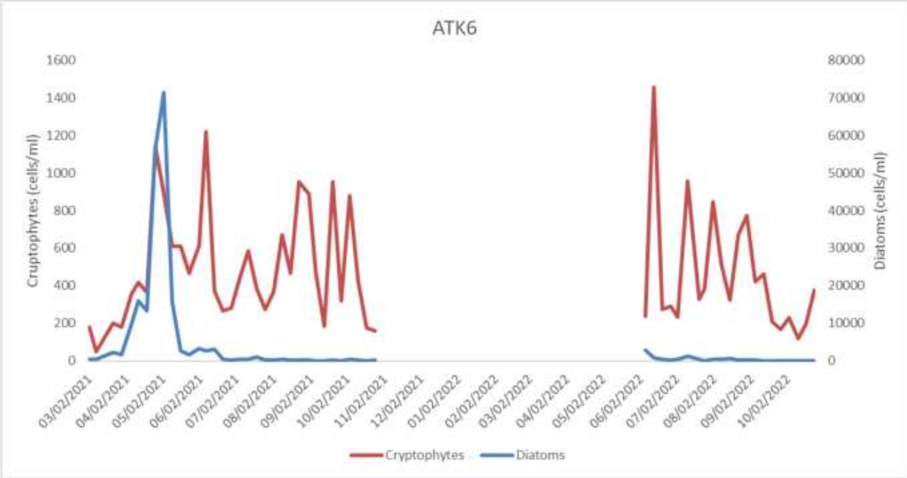
A.2.48 The data suggests growing conditions at the sites were not often suitable to allow a period of rapid growth for either the Diatoms or Cryptophytes. Instead, the sustained lower concentrations indicate conditions were favourable to a low level of sustained growth with the occasional more rapid increases in abundance, but the Diatoms and Cryptophytes may have been outcompeted for the available nutrients by the Cyanobacteria, Meso-green and Pico-green algae.

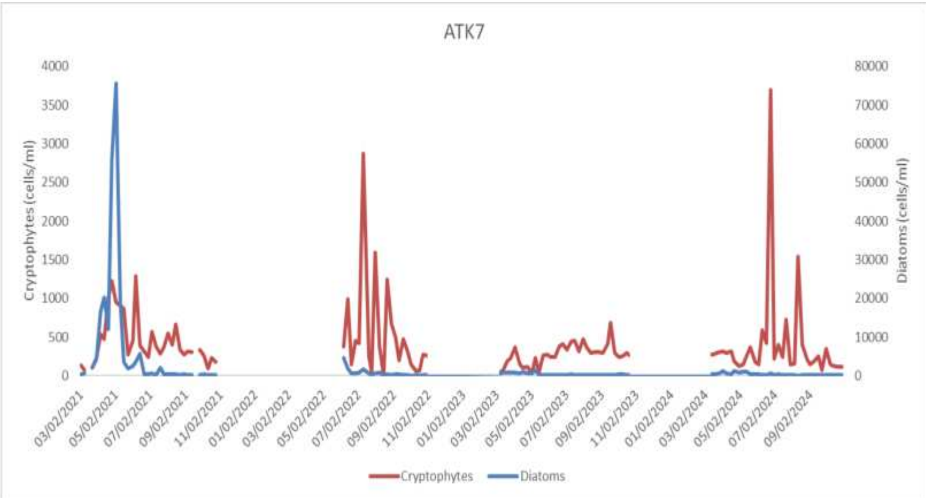
Plate A.7 Cryptophyte and Diatom seasonal growth patterns at each site: Please note the difference in axis ranges.











Analysis of the relationship between SRP and phytoplankton levels.

A.2.49 Phosphorus is an essential nutrient for algal and cyanobacterial growth and is often the limiting nutrient within a freshwater ecosystem. High concentrations of phosphorus can lead to eutrophic conditions where surplus nutrients are present within the water, increasing the risk of algal and cyanobacterial blooms and water quality deterioration.

A.2.50 However, other factors can directly and indirectly affect the growth of algae and cyanobacteria, including low concentrations of other key nutrients (e.g. silicon for diatoms) and weather conditions which affect conditions within the water. In addition, factors such as nutrient ratios play a key part when determining the risk of blooms. Therefore, many factors come together to influence the seasonal growth patterns observed in a freshwater ecosystem (positively or negatively).

A.2.51 Analysis of phytoplankton levels in relation to Soluble Reactive Phosphorus (SRP) levels at each site over time was conducted to try to establish whether SRP is a limiting factor to algal growth in the River Thames within and close to the Study Area.

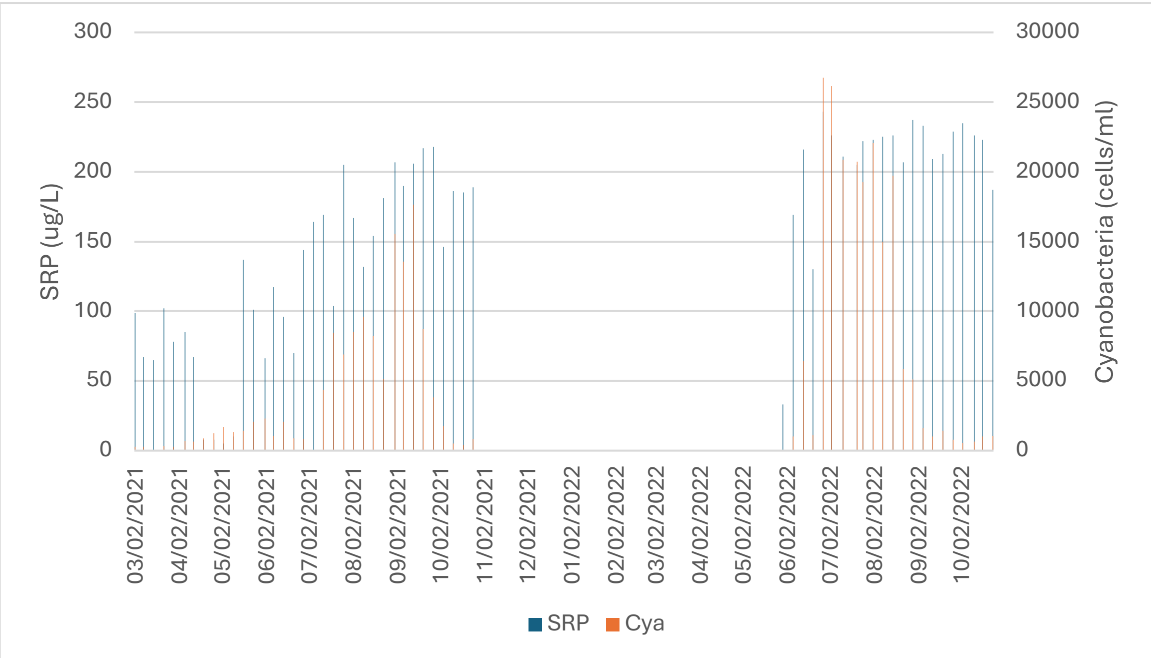
ATK5 Walton (freshwater River Thames)

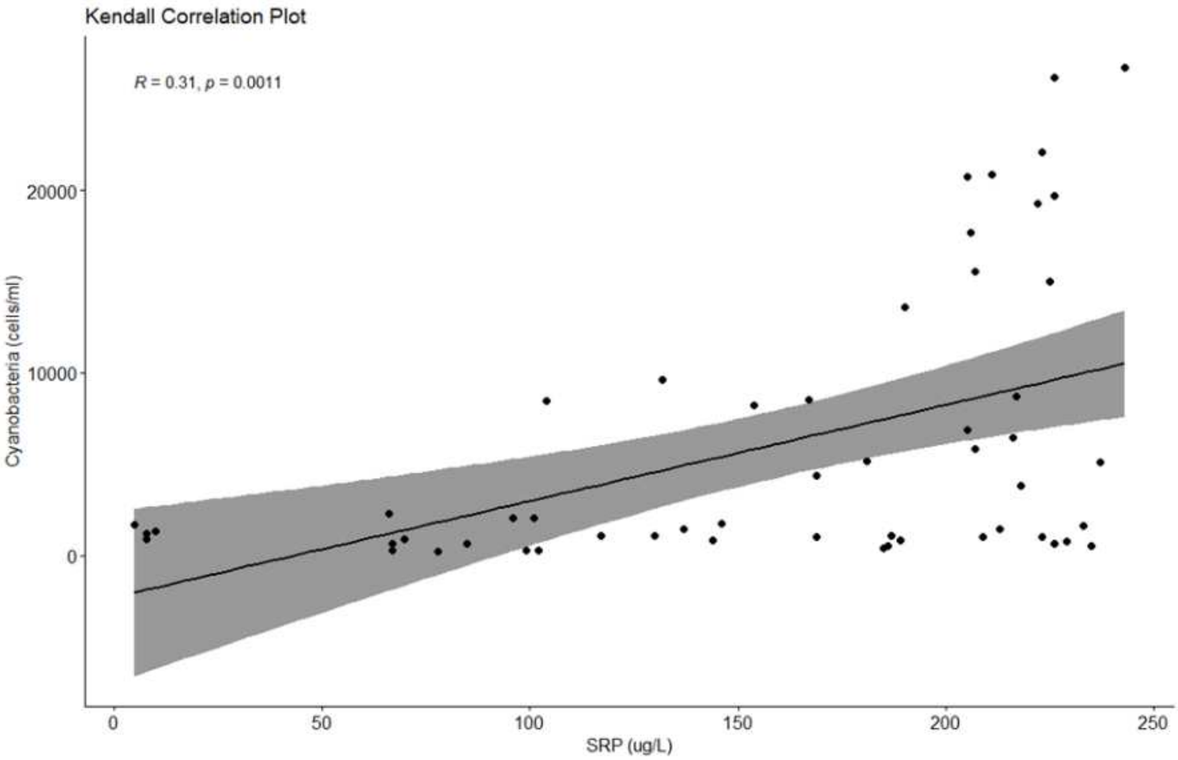
SRP - Cyanobacteria

A.2.52 Cyanobacterial numbers increased during late summer of 2021 and 2022 with increasing SRP concentrations over the summer period and the autumn of 2022. However, cyanobacterial numbers decreased during periods of sustained SRP concentrations; the decrease is likely at least in part a result of colder water conditions. Increased SRP concentrations during early summer did not result in a spike in cyanobacterial numbers, suggesting cyanobacterial numbers were unlikely to be influenced by SRP concentration alone.

A.2.53 A significantly positive (P<0.005) and strong (tau>0.3) correlation was determined between SRP concentrations and cyanobacetrial count, indicating an increase in SRP coincided with an increase in cyanobacetrial abundance. However, other factors also influenced the abundance of cyanobacterial cells at this site.

Plate A.8 A comparison between Cyanobacterial numbers and SRP concentrations (top) and correlation assessment between SRP concentrations and Cyanobacterial numbers (bottom) using Kendall’s tau (Key: Strong correlation: tau =>0.3; moderate correlation: tau = 0.2 – 0.29; weak correlation: 0.1 – 0.19).



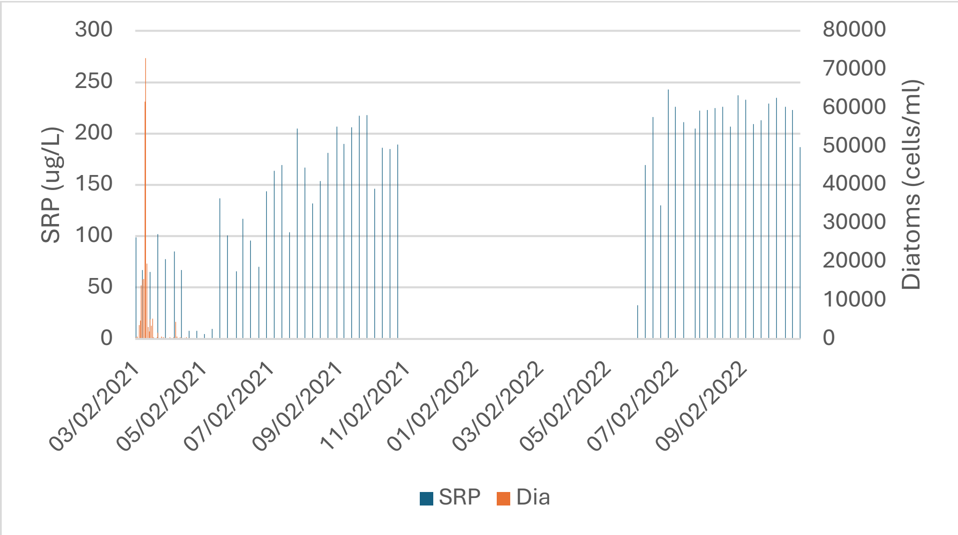


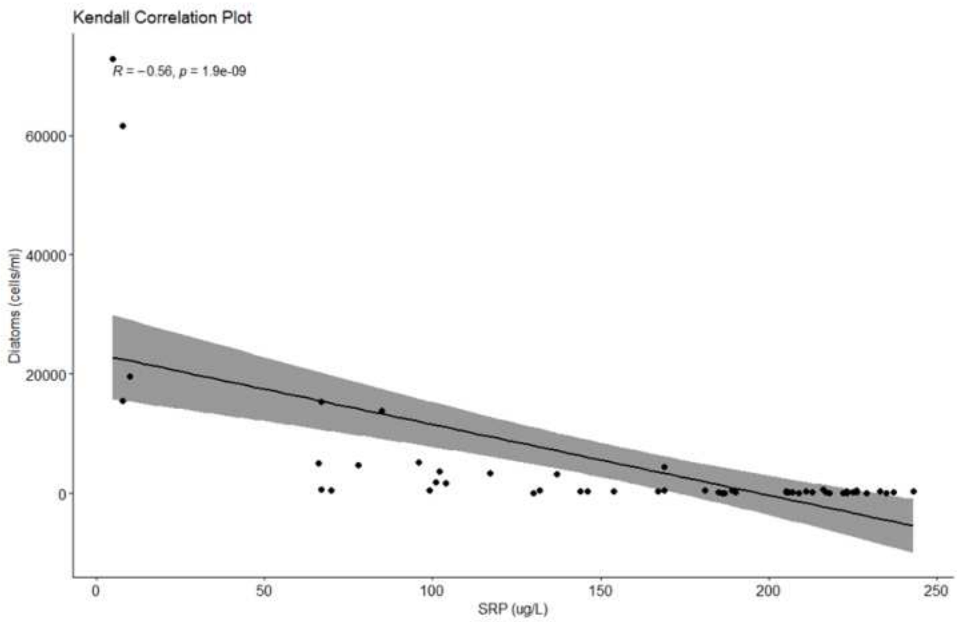
SRP - Diatoms

A.2.54 Diatom numbers spiked during March 2021 but such abundance was not recorded afterwards despite increasing concentrations of SRP over the growing seasons (spring/summer and autumn). This suggests SRP is not the limiting factor for diatom growth at this site.

A.2.55 A significantly negative (P<0.001) correlation was determined between SRP concentrations and Diatom count, with the correlation indicated to be a strong correlation (tau > 0.3). This may be influenced by a number of outliers identified during 2021.

Plate A.9 A comparison between Diatom numbers and SRP concentrations (top) and correlation assessment between SRP concentrations and Diatom numbers (bottom) using Kendall’s tau (Key: Strong correlation: tau =>0.3; moderate correlation: tau = 0.2 – 0.29; weak correlation: 0.1 – 0.19).



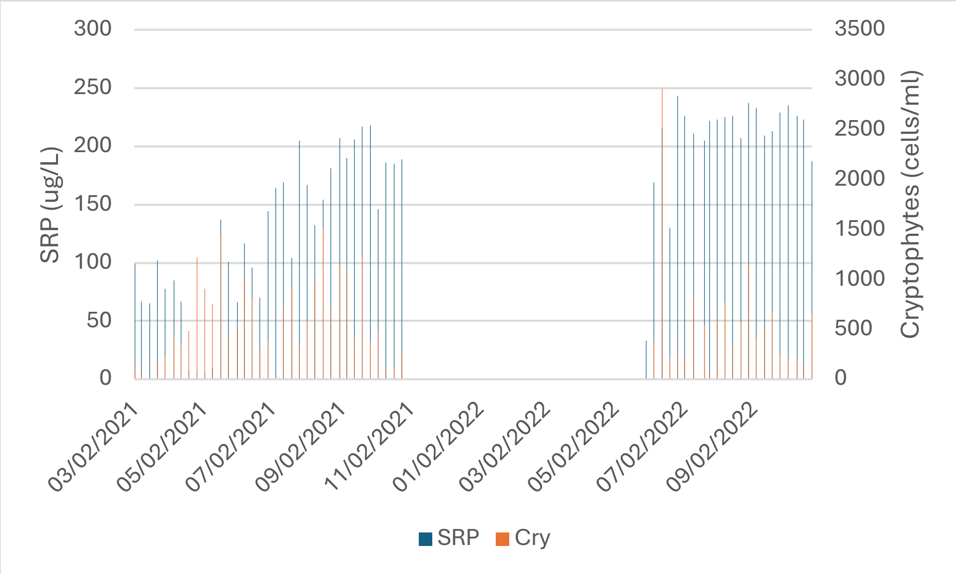


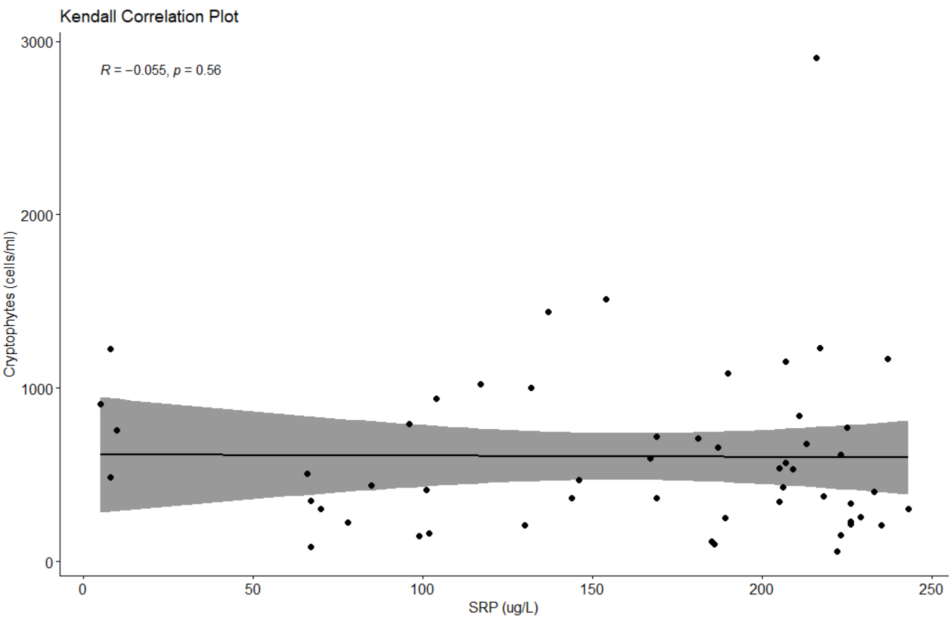
SRP - Cryptophytes

A.2.56 Cryptophyte numbers generated one dominant spike which occurred during the summer of 2022. The seasonal growth pattern of the cryptophytes over the sampling period demonstrated decreases in abundance during periods of raised SRP conditions during the summer of 2022 relative to lower SRP concentrations over the growing season of 2021, indicating the influence of other factors upon the cryptophyte growth patterns, suggesting SRP is not the limiting factor for diatom growth at this site.

A.2.57 The correlation between SRP concentrations and Cryptophyte count was both insignificant (P>0.05) and extremely weak (tau < 0.1), suggesting SRP alone did not determine the abundance of Cryptophytes

Plate A.10 A comparison between Cryptophyte numbers and SRP concentrations (top) and correlation assessment between SRP concentrations and Cryptophyte numbers (bottom) using Kendall's tau (Key: Strong correlation: tau =>0.3; moderate correlation: tau = 0.2 – 0.29; weak correlation: 0.1 – 0.19).



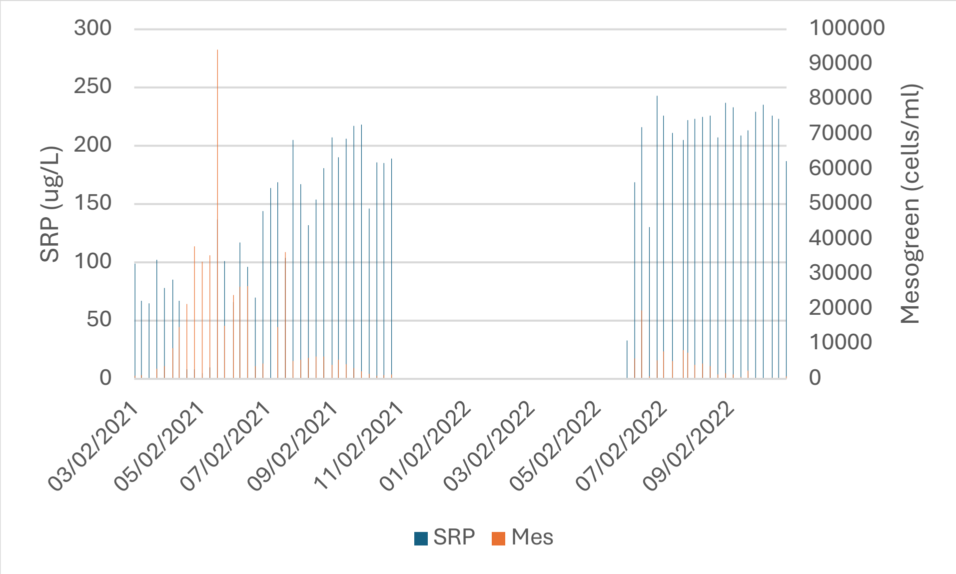


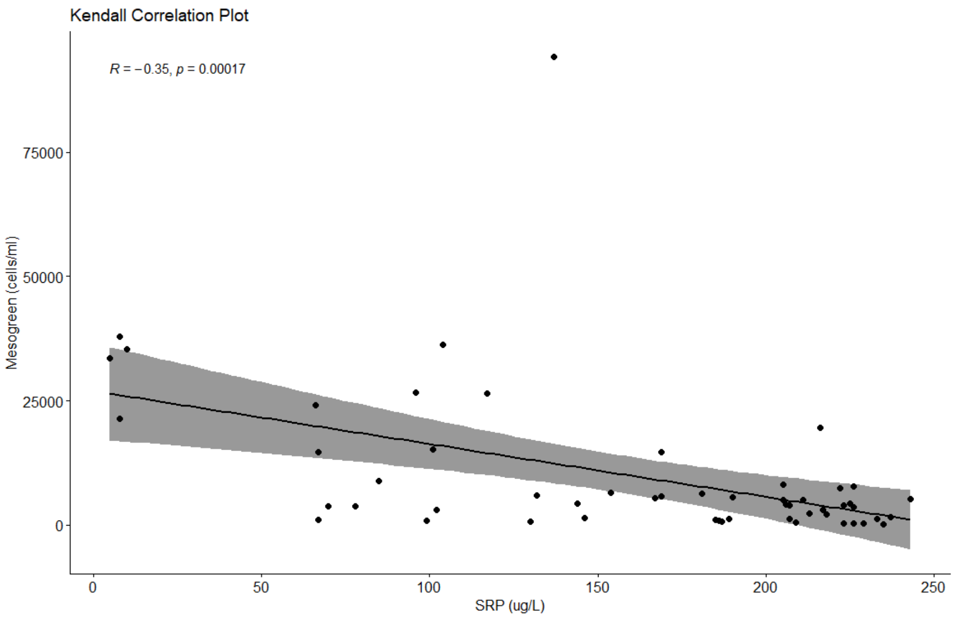
SRP – Meso-green algae

A.2.58 Meso-green algae numbers spiked during 2021, but such abundance was not recorded again despite increasing concentrations of SRP over the growing seasons (spring/summer and autumn) during 2022. This suggests SRP was not the limiting factor for meso-green algae growth at this site.

A.2.59 A significantly negative (P<0.001) correlation was determined between SRP concentrations and meso-green algae count, with the correlation indicated to be a strong correlation (tau = >0.3). The data suggests an increase in meso-green algae may occur concurrently with a decrease in SRP, indicating assimilation to be, at least in part, the reason for decreasing SRP concentrations.

Plate A.11 A comparison between Meso-green algae numbers and SRP concentrations (top) and correlation assessment between SRP concentrations and Meso-green algae numbers (bottom) using Kendall's tau (Key: Strong correlation: tau =>0.3; moderate correlation: tau = 0.2 – 0.29; weak correlation: 0.1 – 0.19).



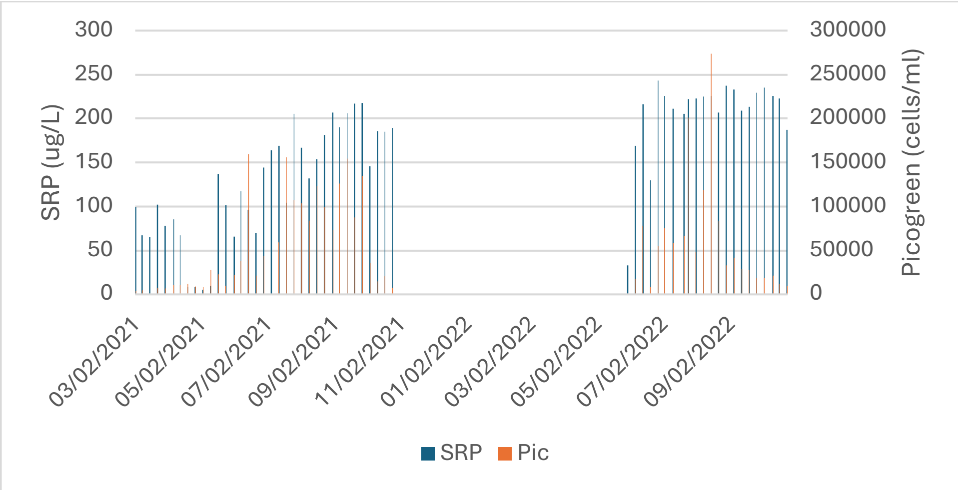


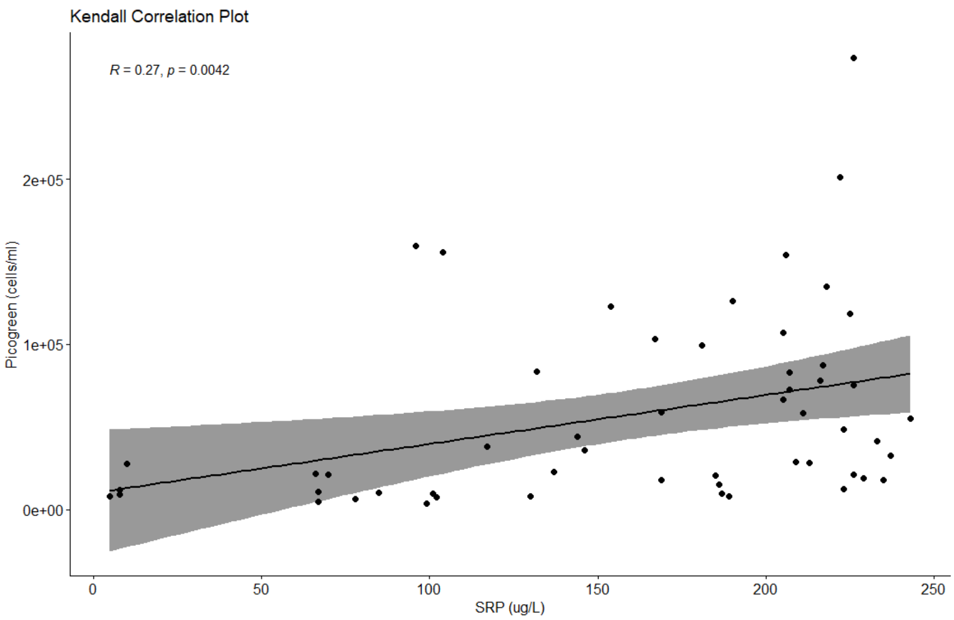
SRP – Pico-green algae

A.2.60 Pico-green algae numbers regularly recorded peaks over the sampling period indicating favourable growing conditions. A decrease in cellular abundance was recorded as the summer period came to an end during 2021 and 2022 and was therefore likely a response to colder conditions. The higher SRP concentrations recorded over the growing season of 2022 relative to that of 2021 did not result in greater abundance, indicating SRP was not the only limiting factor at this site.

A.2.61 The positive correlation between SRP concentrations and pico-green algae count was significant (P<0.005) and moderate (tau =0.27), suggesting an increase in SRP concentrations is likely to result in an increase in pico-green algae abundance, but also that SRP alone did not determine the abundance of pico-green algae.

Plate A.12 A comparison between Picogreen algae numbers and SRP concentrations (top) and correlation assessment between SRP concentrations and Picogreen algae numbers (bottom) using Kendall's tau (Key: Strong correlation: tau =>0.3; moderate correlation: tau = 0.2 – 0.29; weak correlation: 0.1 – 0.19).





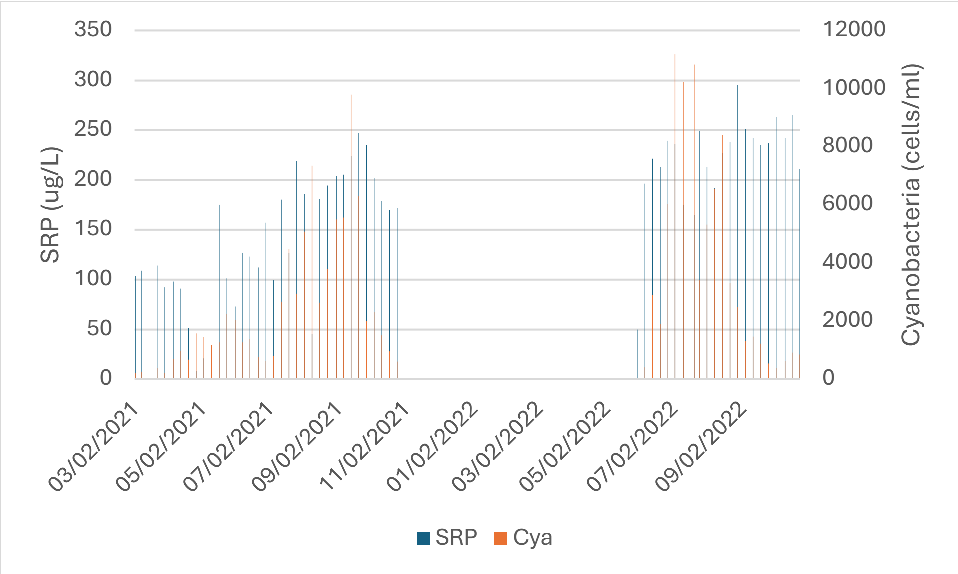
ATK6 Surbiton (freshwater River Thames)

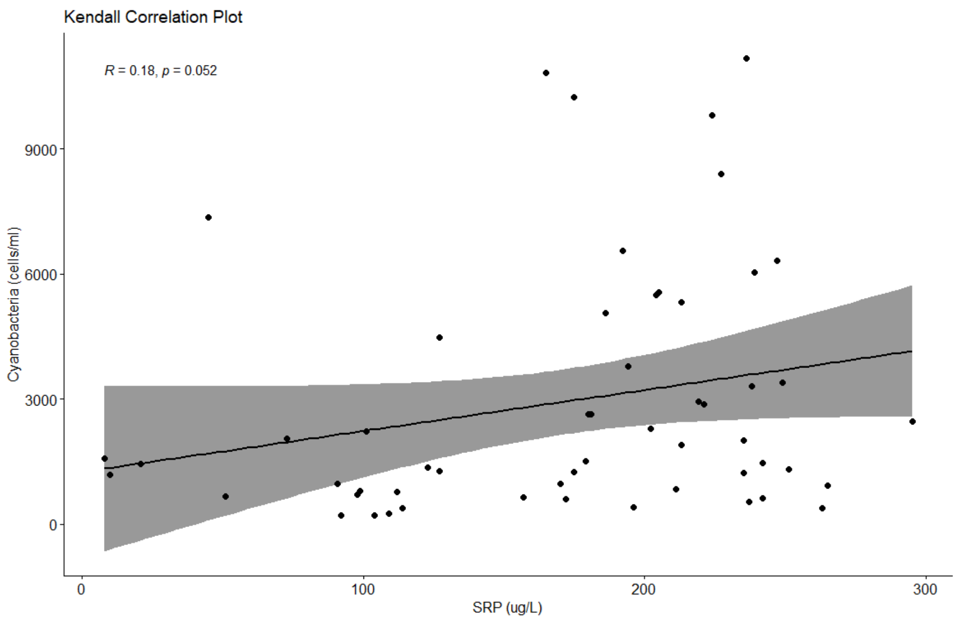
SRP - Cyanobacteria

A.2.62 Cyanobacterial numbers increased with increasing SRP concentrations, however, a decrease in cyanobacterial numbers was likely due to the return of cooler water temperatures at the end of the autumnal season. Increased SRP concentrations observed during the mid summer of 2022 did not result in higher cyanobacterial abundance, indicating the influence of other factors upon cyanobacteria growth. However, it appears raised SRP concentrations were more likely to result in increased cyanobacterial abundance and therefore weighted more heavily upon the cyanobacterial community relative to the growth of algae at this site.

A.2.63 The correlation between SRP concentrations and cyanobacteria was both insignificant (P>0.05) and weak (tau < 0.18), suggesting SRP alone did not determine the abundance of cyanobacteria.

Plate A.13 A comparison between Cyanobacteria numbers and SRP concentrations (top) and correlation assessment between SRP concentrations and Cyanobacteria numbers (bottom) using Kendall's tau (Key: Strong correlation: tau =>0.3; moderate correlation: tau = 0.2 – 0.29; weak correlation: 0.1 – 0.19).



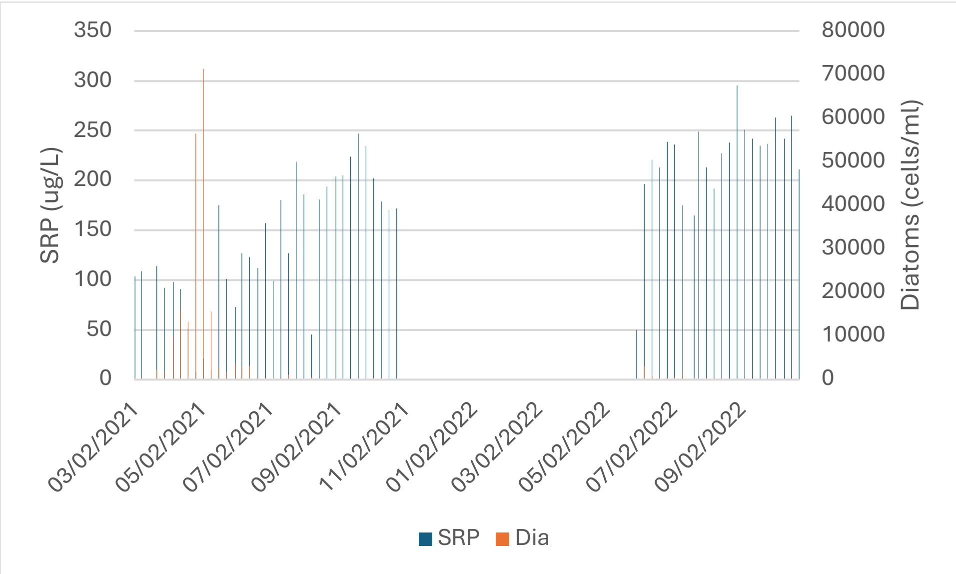


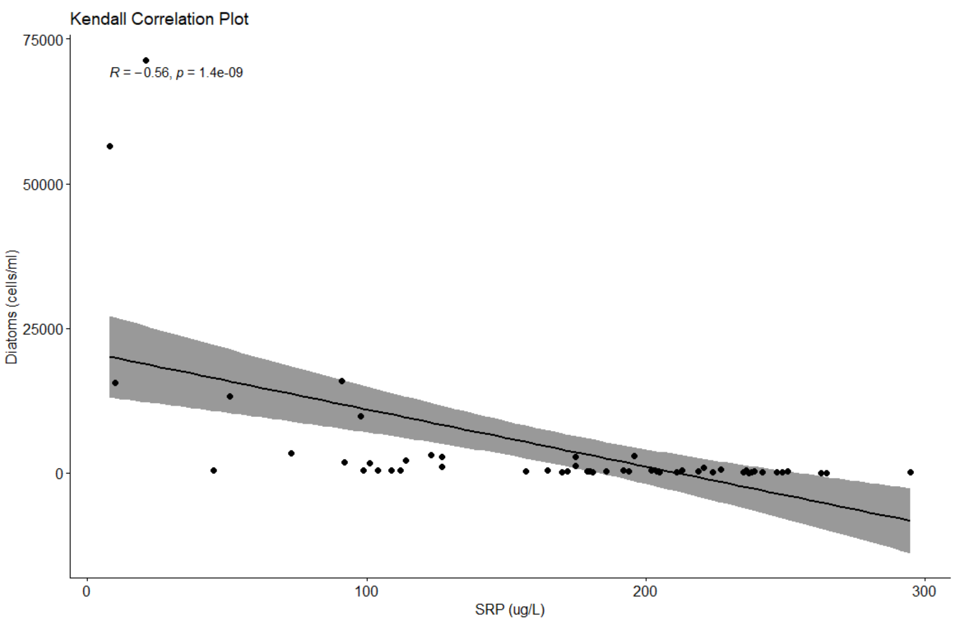
SRP - Diatoms

A.2.64 Diatom numbers spiked during spring 2021 but such abundance was not recorded afterwards despite increasing concentrations of SRP over the growing seasons (spring/summer and autumn). This suggests SRP is not the limiting factor for diatom growth at this site.

A.2.65 A significantly negative (P<0.001) correlation was determined between SRP concentrations and diatom count, with the correlation indicated to be a strong correlation (tau > 0.3). This may be influenced by a number of outliers identified during 2021.

Plate A.14 A comparison between Diatom numbers and SRP concentrations (top) and correlation assessment between SRP concentrations and Diatom numbers (bottom) using Kendall's tau (Key: Strong correlation: tau =>0.3; moderate correlation: tau = 0.2 – 0.29; weak correlation: 0.1 – 0.19).



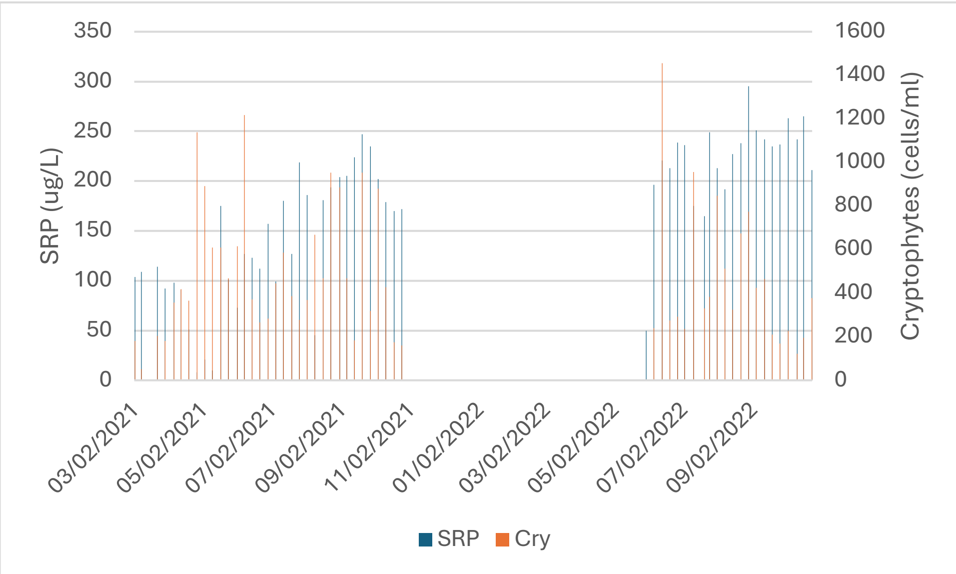


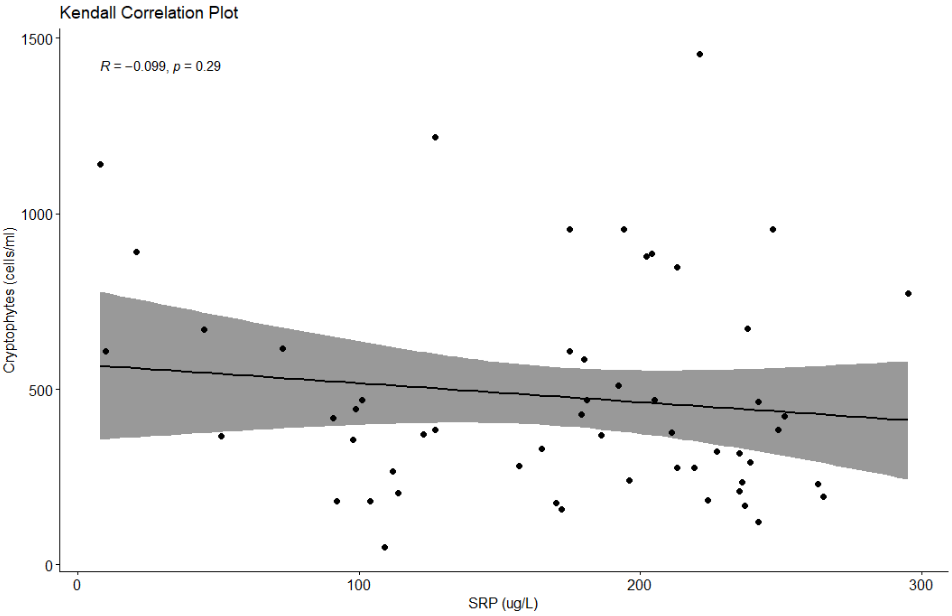
SRP - Cryptophytes

A.2.66 Cryptophyte numbers generated several spikes over the sampling period indicating sustained favourable growing conditions. Raised SRP concentrations over the growing season of 2022 did not coincide with an increase in Cryptophyte numbers relative to that of 2021, indicating the influence of other factors upon the cryptophyte growth patterns, suggesting SRP was not the only limiting factor for diatom growth at this site.

A.2.67 The correlation between SRP concentrations and Cryptophyte count was both insignificant (P>0.05) and extremely weak (tau < 0.1), suggesting SRP alone did not determine the abundance of Cryptophytes.

Plate A.15 A comparison between Cryptophyte numbers and SRP concentrations (top) and correlation assessment between SRP concentrations and Cryptophyte numbers (bottom) using Kendall's tau (Key: Strong correlation: tau =>0.3; moderate correlation: tau = 0.2 – 0.29; weak correlation: 0.1 – 0.19).



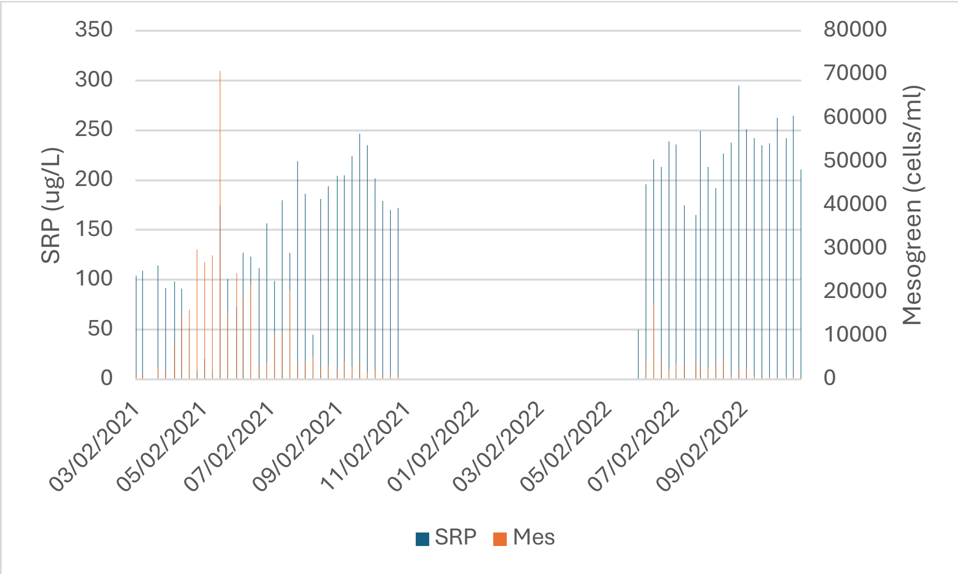


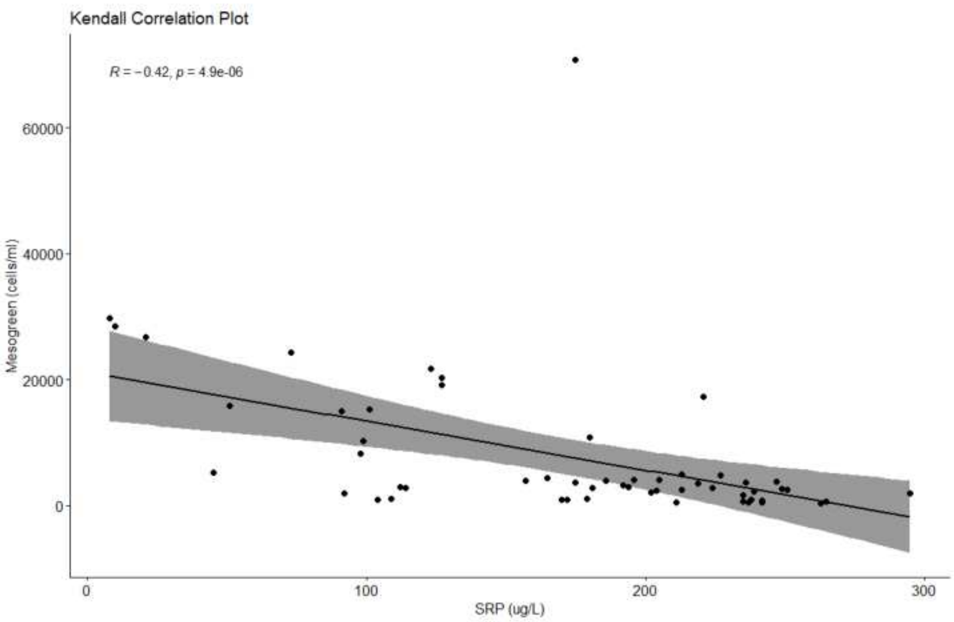
SRP – Meso-green algae

A.2.68 Meso-green algae numbers spiked during 2021, but such abundance was not recorded again despite increasing concentrations of SRP over the growing season of 2022 relative to that of 2021 (spring/summer and autumn). This suggests SRP was not the limiting factor for meso-green algae growth at this site.

A.2.69 A significantly negative ($P<0.001$) correlation was determined between SRP concentrations and meso-green algae count, with the correlation indicated to be a strong correlation (tau = >0.3). The data suggests an increase in meso-green algae may occur concurrently with a decrease in SRP, indicating assimilation to be, at least in part, the reason for decreasing SRP concentrations.

Plate A.16 A comparison between Mesogreen algae numbers and SRP concentrations (top) and correlation assessment between SRP concentrations and Mesogreen algae numbers (bottom) using Kendall's tau (Key: Strong correlation: tau =>0.3; moderate correlation: tau = 0.2 – 0.29; weak correlation: 0.1 – 0.19).



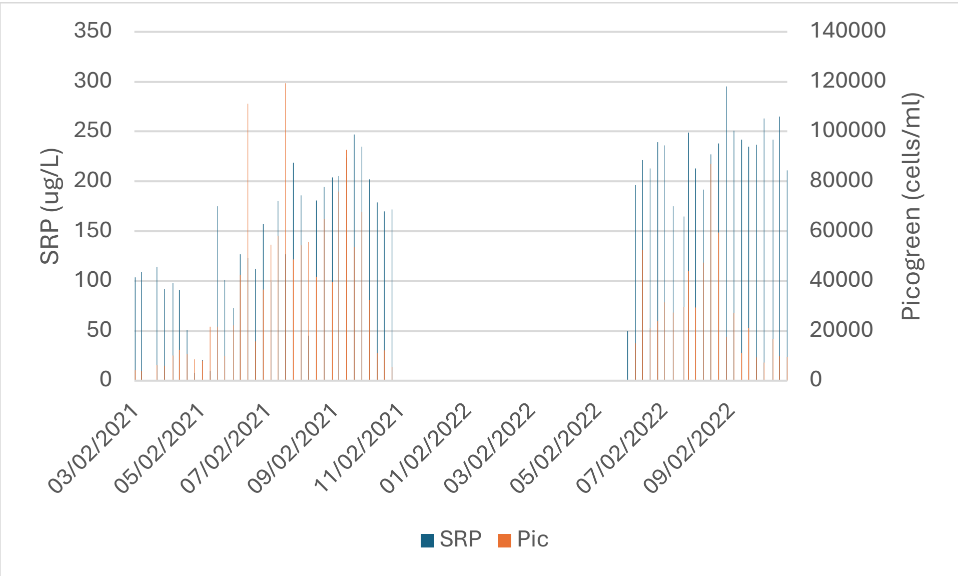


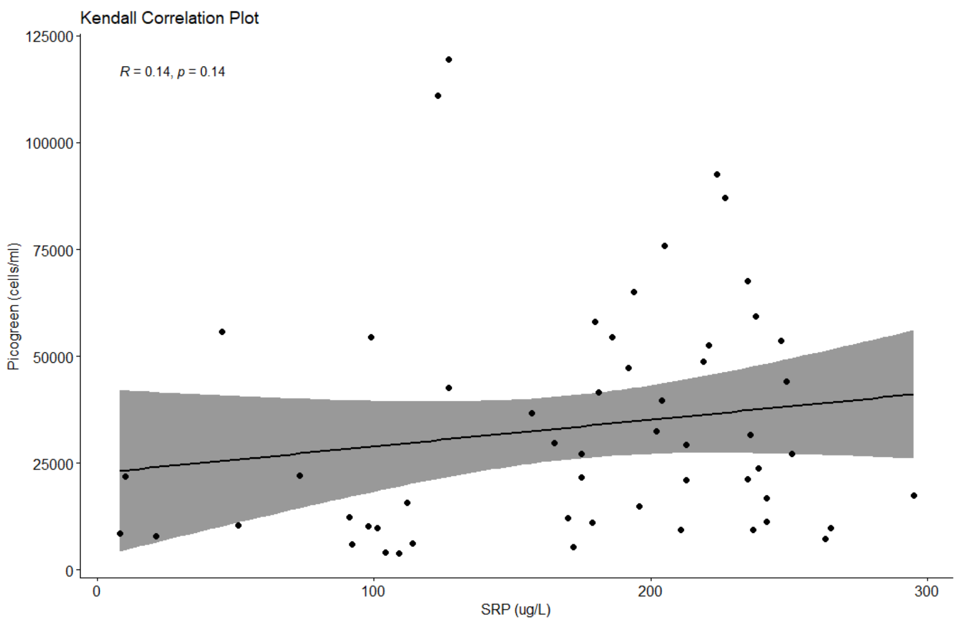
SRP – Pico-green algae

A.2.70 Pico-green algae numbers were higher during the summer of 2021 relative to that of 2022, but SRP was maintained at a higher concentration over the summer of 2022 relative to that of 2021 indicating SRP was not the only limiting factor at this site.

A.2.71 The correlation between SRP concentrations and pico-green count was both insignificant (P>0.05) and weak (tau = 0.14), suggesting SRP alone did not determine the abundance of pico-green algae.

Plate A.17 A comparison between Picogreen algae numbers and SRP concentrations (top) and correlation assessment between SRP concentrations and Picogreen algae numbers (bottom) using Kendall's tau (Key: Strong correlation: tau =>0.3; moderate correlation: tau = 0.2 – 0.29; weak correlation: 0.1 – 0.19).





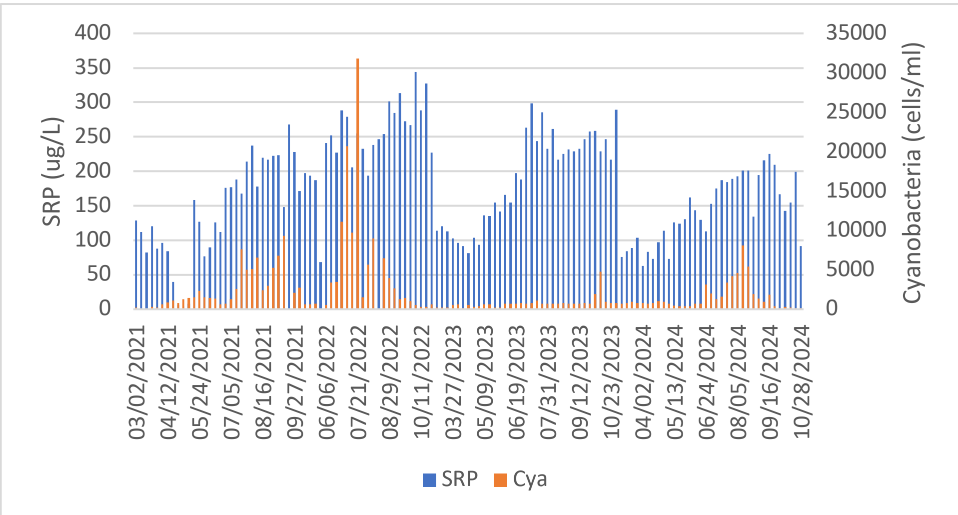
ATK7 – Teddington (freshwater River Thames)

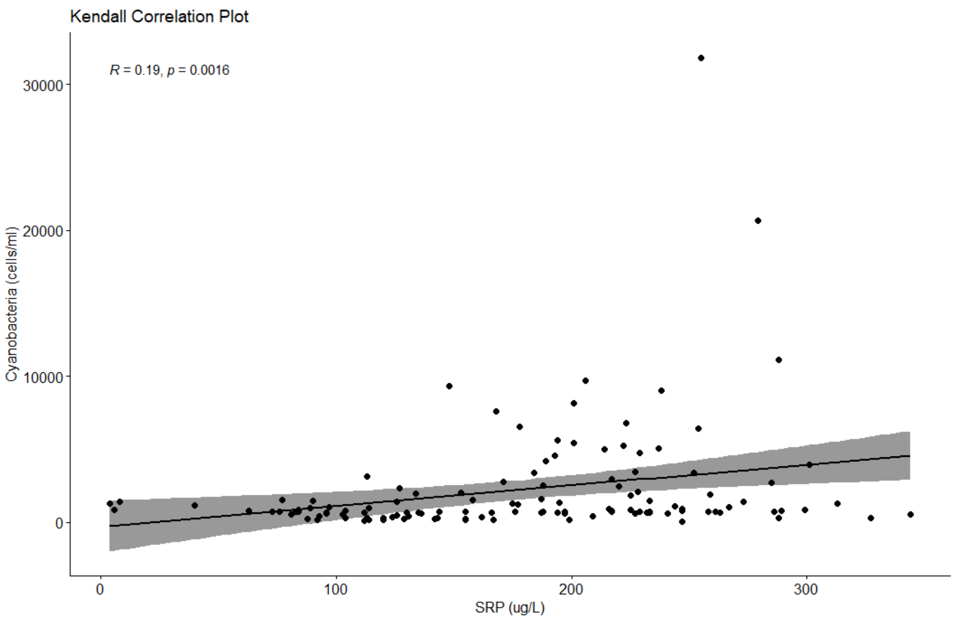
SRP - Cyanobacteria

A.2.72 Cyanobacterial numbers typically increased during the mid-late summer with increasing SRP concentrations, with the exception of the summer of 2023 despite higher SRP concentrations than that recorded during the summer of 2021. Relatively lower cyanobacterial numbers during periods of sustained or increased SRP concentrations, particularly during the spring and summer of 2023, indicate the influence of other factors upon cyanobacterial abundance.

A.2.73 A significantly positive ($P<0.005$) correlation was determined between SRP concentrations and cyanobacetrial count, however, the correlation is deemed to be a weak correlation.

Plate A.18 A comparison between cyanobacterial numbers and SRP concentrations (top) and correlation assessment between SRP concentrations and Cyanobacterial numbers (bottom) using Kendall's tau (Key: Strong correlation: tau =>0.3; moderate correlation: tau = 0.2 – 0.29; weak correlation: 0.1 – 0.19).



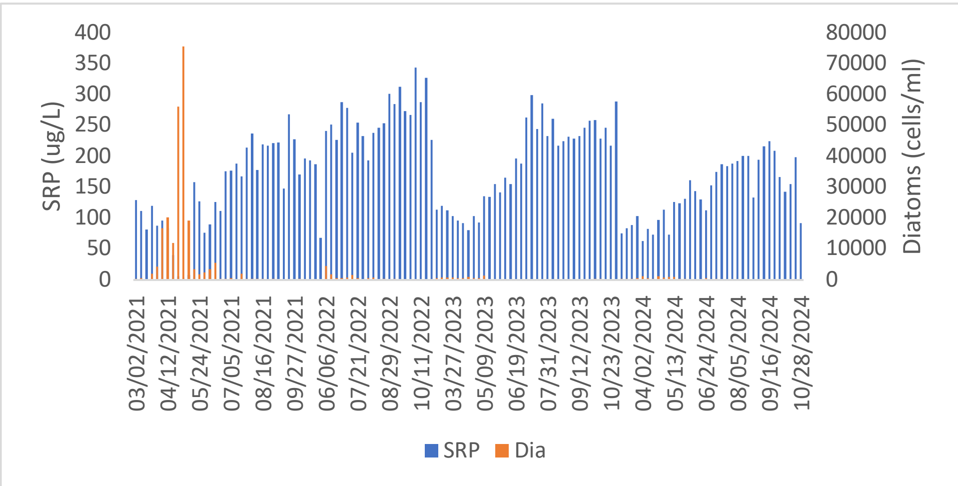


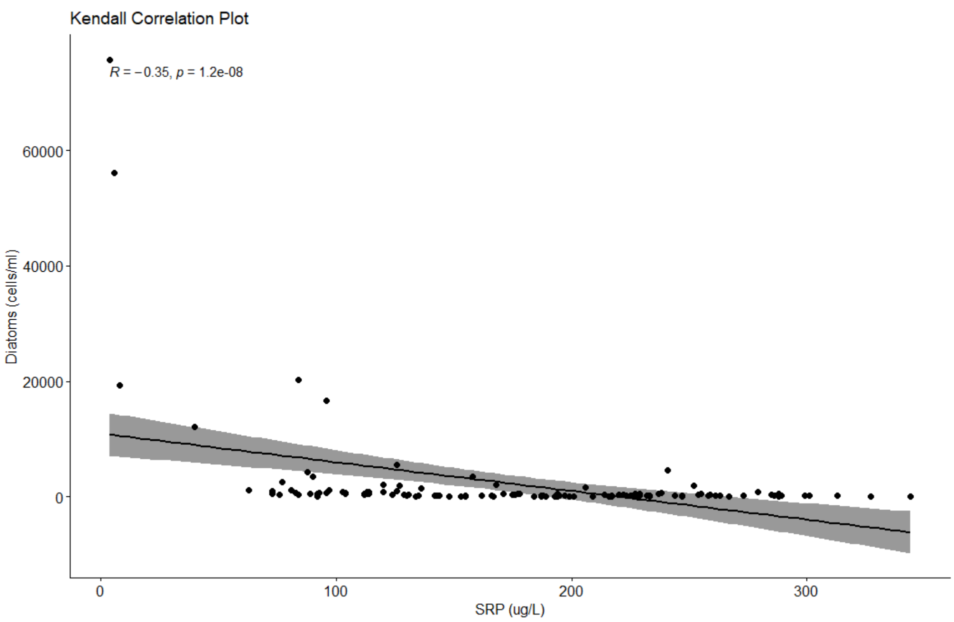
SRP - Diatoms

A.2.74 Diatom numbers spiked during the spring 2021 but such abundance was not recorded afterwards despite increasing concentrations of SRP over the growing seasons (spring/summer and autumn). This suggests SRP was not the limiting factor for diatom growth at this site. Moreover, conditions other than SRP concentrations influenced the diatom community to the extent of resulting in little or no growth over the growing seasons 2022 – 2024.

A.2.75 A significantly negative ($P<0.001$) correlation was determined between SRP concentrations and Diatom count, with the correlation indicated to be a strong correlation (tau > 0.3). This may be influenced by a number of outliers identified during 2021.

Plate A.19 A comparison between Diatom numbers and SRP concentrations (top) and correlation assessment between SRP concentrations and Diatom numbers (bottom) using Kendall's tau (Key: Strong correlation: tau =>0.3; moderate correlation: tau = 0.2 – 0.29; weak correlation: 0.1 – 0.19).



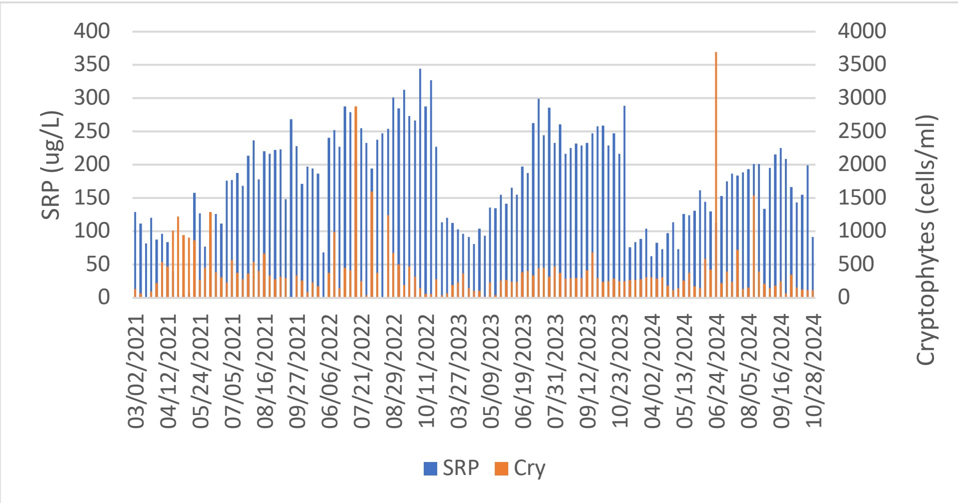


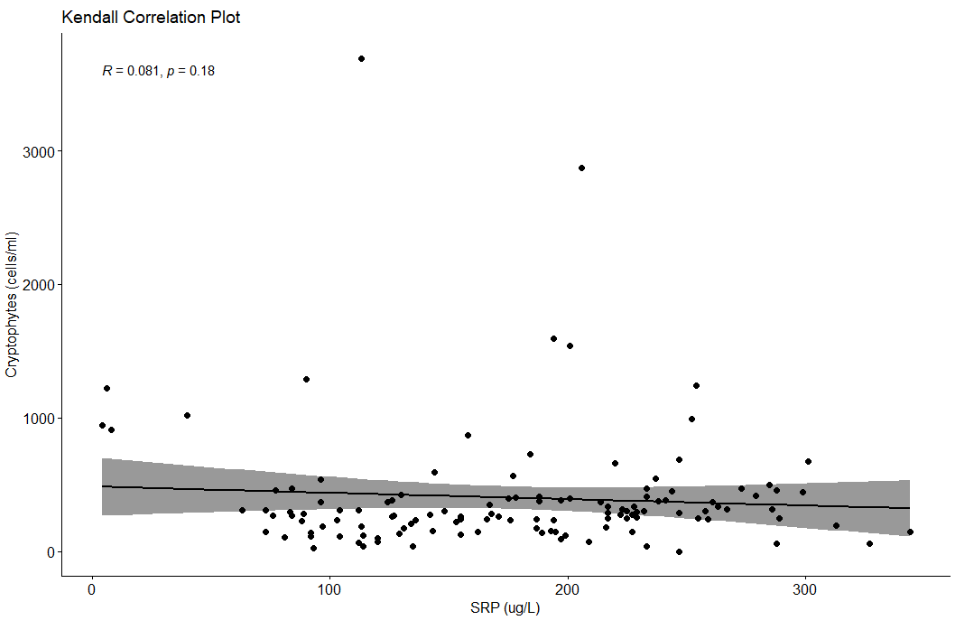
SRP - Cryptophytes

A.2.76 Cryptophyte numbers generated two dominant spikes, the first during 2022 and the second during 2024. The seasonal growth pattern of the cryptophytes over sampling period demonstrated decreases in abundance during periods of raised SRP conditions, particularly throughout 2023, indicating the influence of other factors upon the cryptophyte growth patterns, suggesting SRP was not the limiting factor for diatom growth at this site. However, their growth was sustained through the growing seasons over the years, indicating conditions favourable for the maintained growth of the Cryptophytes albeit with the absence of population spikes during 2023.

A.2.77 The correlation between SRP concentrations and Cryptophyte count was both insignificant (P>0.05) and extremely weak (tau < 0.1), suggesting SRP alone did not determine the abundance of Cryptophytes.

Plate A.20 A comparison between Cryptophyte numbers and SRP concentrations (top) and correlation assessment between SRP concentrations and Cryptophyte numbers (bottom) using Kendall's tau (Key: Strong correlation: tau =>0.3; moderate correlation: tau = 0.2 – 0.29; weak correlation: 0.1 – 0.19).



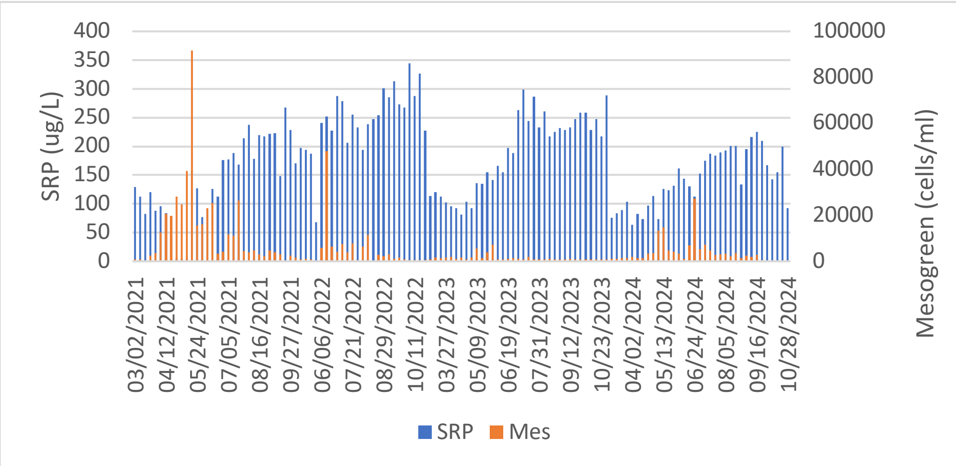


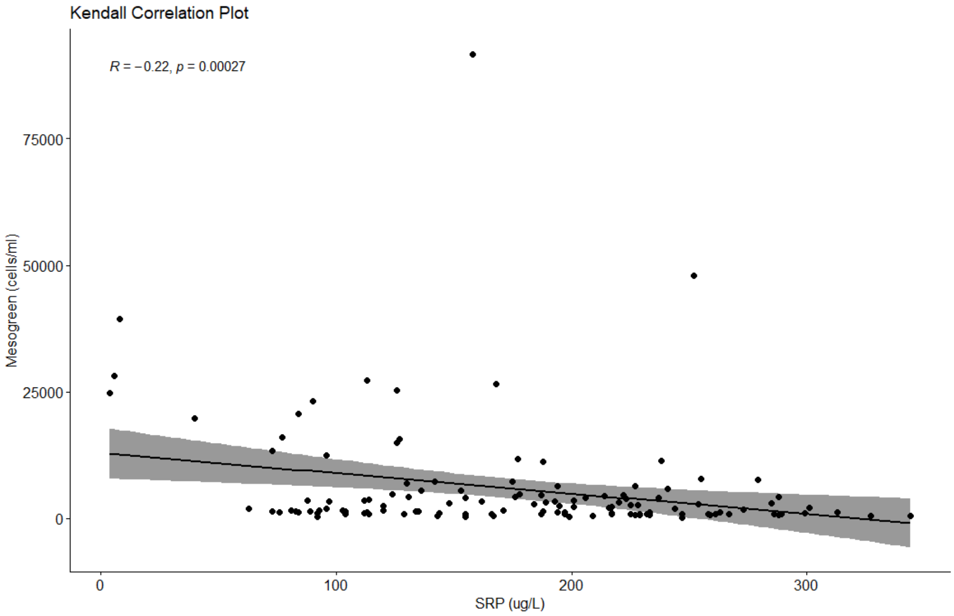
SRP – Meso-green algae

A.2.78 Meso-green algae numbers spiked during spring of 2021 and 2022, but such abundance was not recorded afterwards despite maintained/increasing concentrations of SRP over the growing seasons (spring/summer and autumn) relative to that during 2021. Despite a sustained relatively high SRP concentration throughout the growing season of 2022 and 2023, meso-green algal numbers remained low relative to that over the growing season of 2021. This suggests SRP was not the limiting factor for meso-green algae growth at this site.

A.2.79 A significantly negative (P<0.001) correlation was determined between SRP concentrations and meso-green algae count, with the correlation indicated to be a moderate correlation (tau = -0.22). The data suggests an increase in meso-green algae may occur concurrently with a decrease in SRP, indicating assimilation to be, at least in part, the reason for decreasing SRP concentrations.

Plate A.21 A comparison between Mesogreen algae numbers and SRP concentrations (top) and correlation assessment between SRP concentrations and Mesogreen algae numbers (bottom) using Kendall's tau (Key: Strong correlation: tau =>0.3; moderate correlation: tau = 0.2 – 0.29; weak correlation: 0.1 – 0.19).



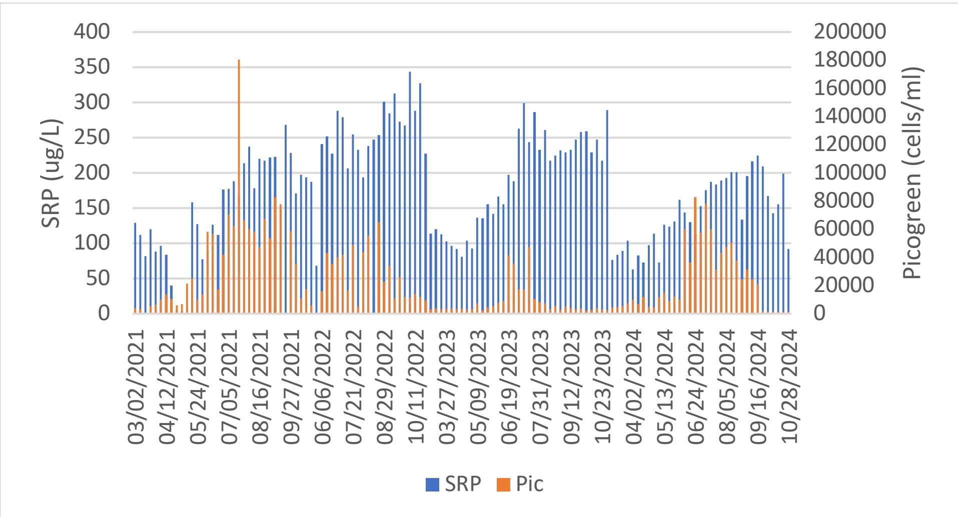


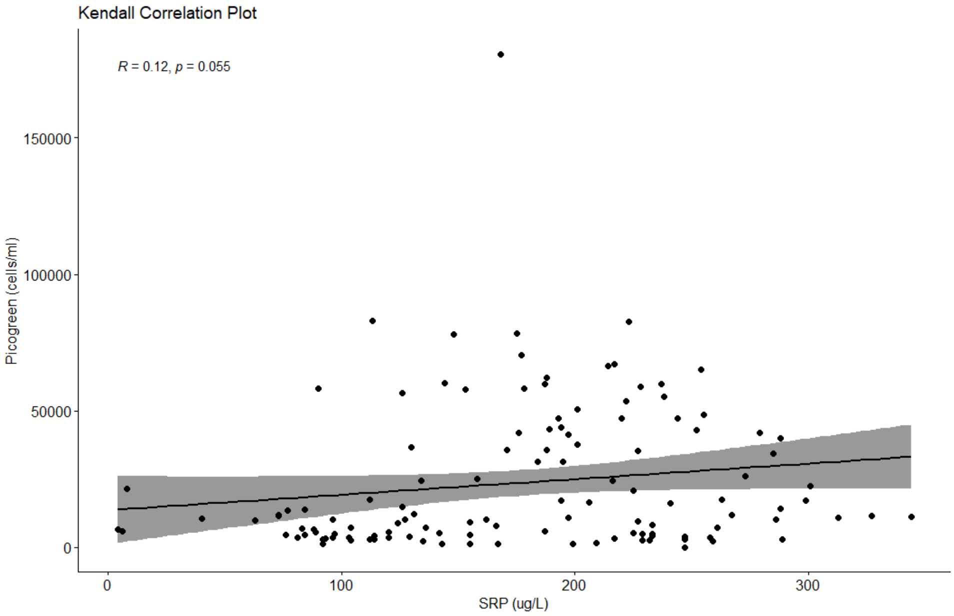
SRP – Pico-green algae

A.2.80 Pico-green algae numbers spiked during 2021 and such abundance was not recorded afterwards despite relatively high concentrations of SRP over the growing seasons (spring/summer and autumn) during 2022 and 2023 relative to that of 2021 and 2024, the latter two years which recorded higher pico-green algae abundance relative to that of 2023. This suggests SRP is not the limiting factor for pico-green growth at this site.

A.2.81 The correlation between SRP concentrations and pico-green algae count was both insignificant (P>0.05) and weak (tau =0.12), suggesting SRP alone did not determine the abundance of pico-green algae.

Plate A.22 A comparison between Picogreen algae numbers and SRP concentrations (top) and correlation assessment between SRP concentrations and Picogreen algae numbers (bottom) using Kendall's tau (Key: Strong correlation: tau =>0.3; moderate correlation: tau = 0.2 – 0.29; weak correlation: 0.1 – 0.19).





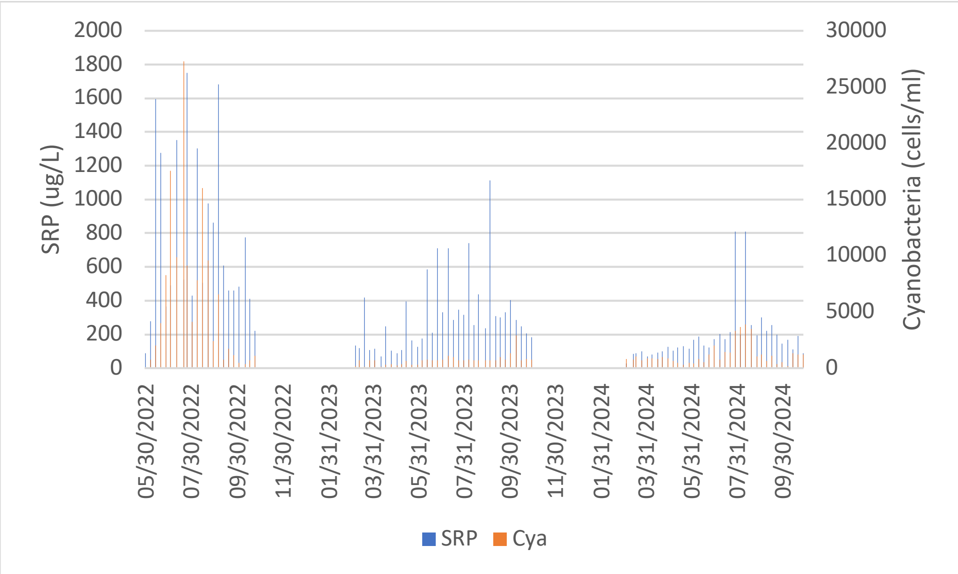
ATK28 Richmond Pound 2 (tidal River Thames)

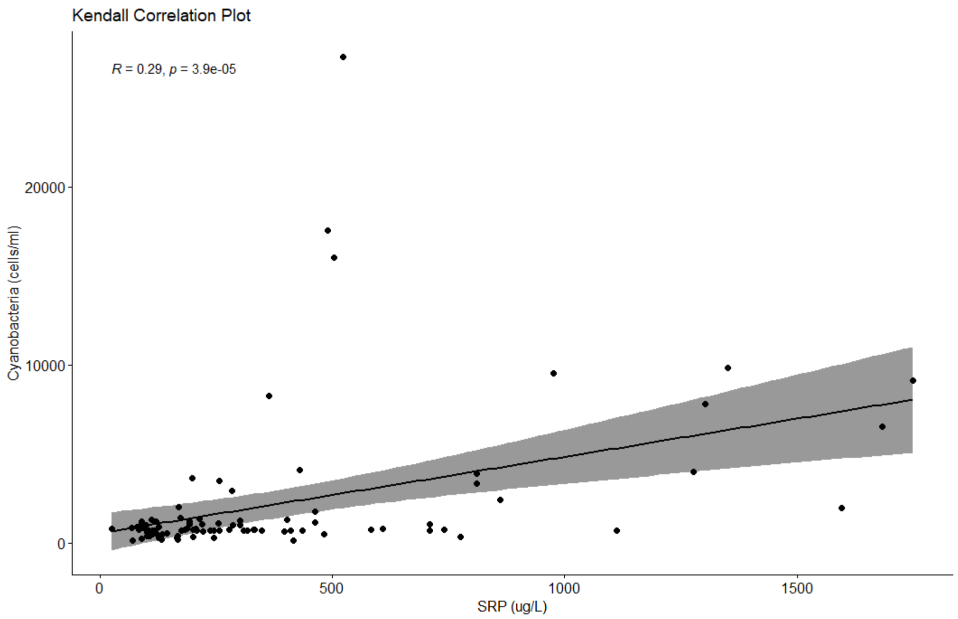
SRP - Cyanobacteria

A.2.82 Cyanobacterial numbers were higher over the summer of 2022 relative to that during 2023 and 2024, however, the SRP concentrations were also lower, suggesting an influence upon cyanobacterial growth. Despite the lower SRP concentration over the growing season of 2024 relative to that of 2023, cyanobacterial numbers were higher, indicating numerous factors are influencing the growth of cyanobacteria at the site. However, it appears raised SRP concentrations were more likely to result in increased cyanobacterial abundance and therefore weighted more heavily upon the cyanobacetrial community relative to the growth of algae at this site.

A.2.83 A significantly positive ($P<0.005$) correlation was determined between SRP concentrations and cyanobacetrial count, and the correlation is deemed to be moderate (tau = 0.29)

Plate A.23 A comparison between Cyanobacterial numbers and SRP concentrations (top) and correlation assessment between SRP concentrations and Cyanobacterial numbers (bottom) using Kendall's tau (Key: Strong correlation: tau =>0.3; moderate correlation: tau = 0.2 – 0.29; weak correlation: 0.1 – 0.19).



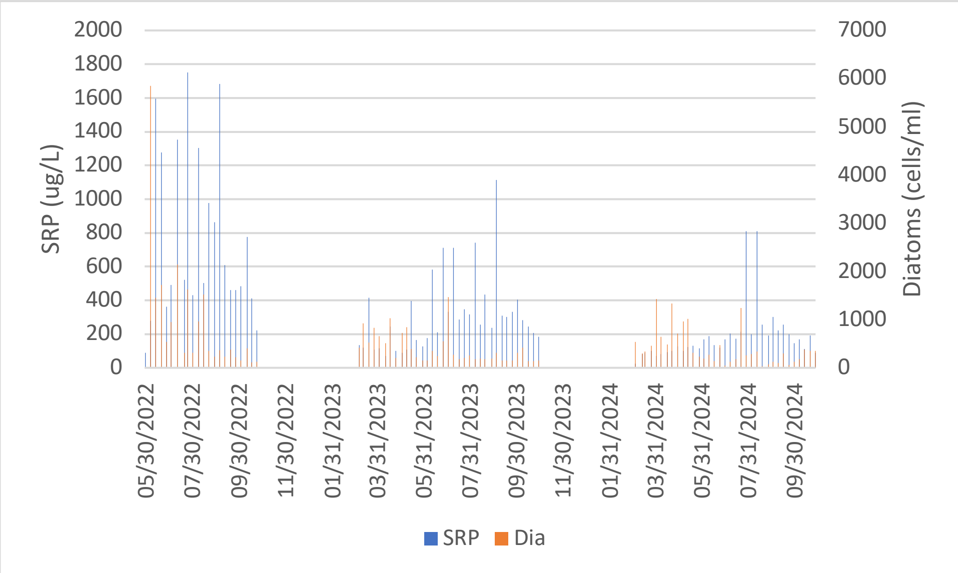


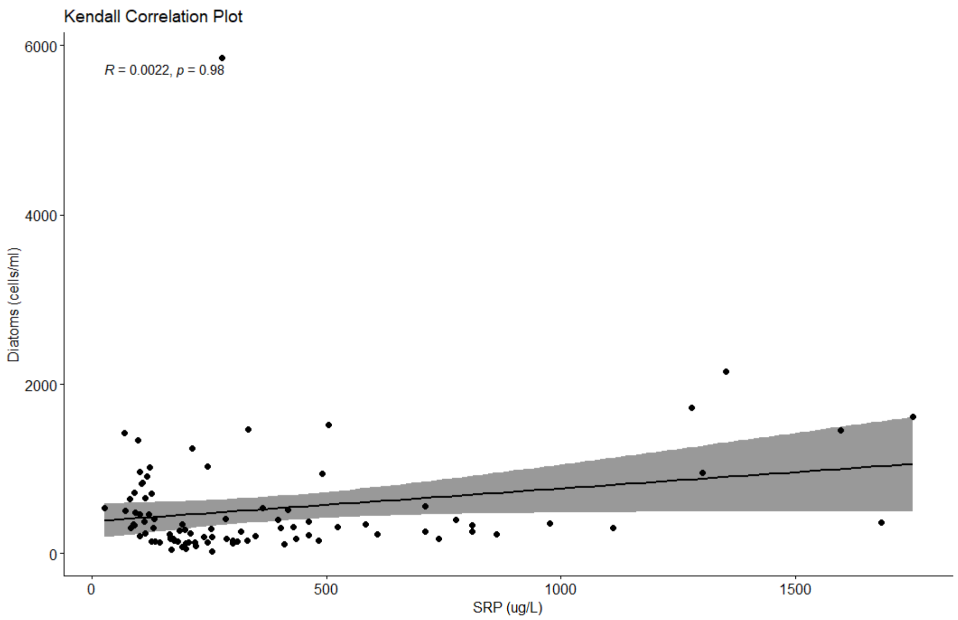
SRP - Diatoms

A.2.84 Diatom numbers spiked during 2022 but such abundance was not recorded afterwards. The SRP concentrations were lower during 2023 and 2024 relative to that of 2022, which may have influenced the diatom abundance. However, decreased diatom growth was recorded during periods of SRP spikes during the summer of 2023 and 2024, suggesting SRP is not the limiting factor for diatom growth at this site.

A.2.85 The correlation between SRP concentrations and diatom count was both insignificant (P>0.05) and extremely weak (tau <0.1), suggesting SRP alone did not determine the abundance of diatoms.

Plate A.24 A comparison between Diatom numbers and SRP concentrations (top) and correlation assessment between SRP concentrations and Diatom numbers (bottom) using Kendall’s tau (Key: Strong correlation: tau =>0.3; moderate correlation: tau = 0.2 – 0.29; weak correlation: 0.1 – 0.19).



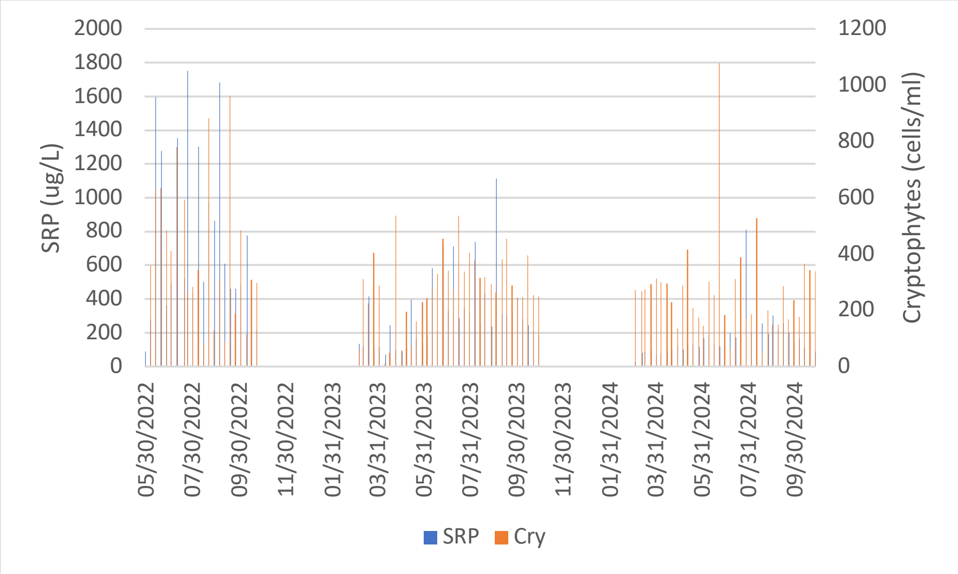


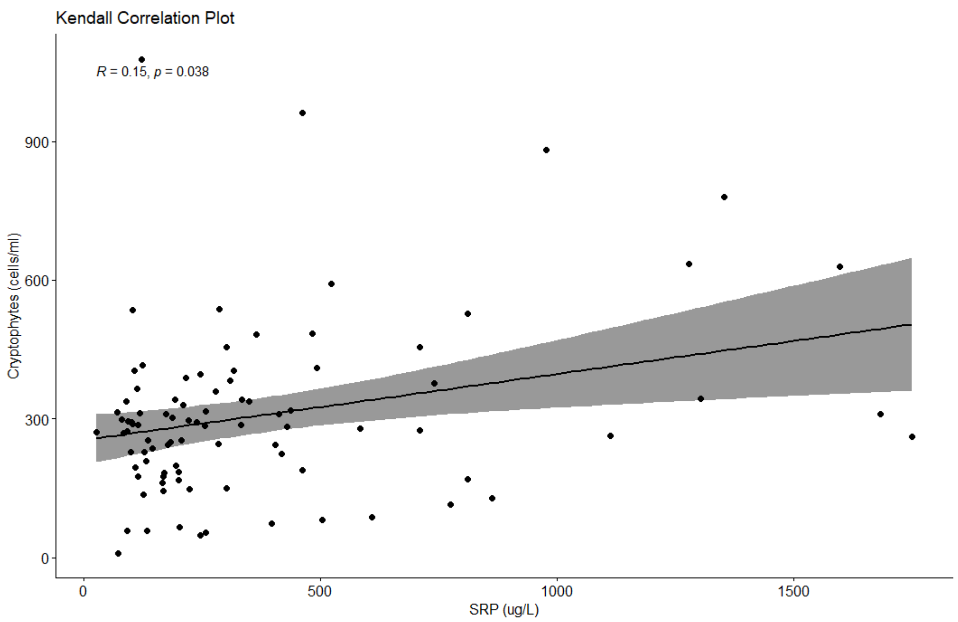
SRP - Cryptophytes

A.2.86 Cryptophyte numbers generated several spikes over the sampling period indicating sustained favourable growing conditions. Cryptophyte growth was maintained over the sampling period seemingly irrespective of the SRP concentrations (relative to other sites) indicating the influence of other factors upon the cryptophyte growth patterns, suggesting SRP was not a limiting factor for growth at this site.

A.2.87 A significantly negative (P<0.05) correlation was determined between SRP concentrations and Cryptophyte algae count, with the correlation indicated to be a weak correlation (tau = 0.15). The data suggests an increase in Cryptophytes may occur concurrently with a decrease in SRP, suggesting assimilation to be, at least in part, the reason for decreasing SRP concentrations.

Plate A.25 A comparison between Cryptophyte numbers and SRP concentrations (top) and correlation assessment between SRP concentrations and Cryptophyte numbers (bottom) using Kendall's tau (Key: Strong correlation: tau =>0.3; moderate correlation: tau = 0.2 – 0.29; weak correlation: 0.1 – 0.19).



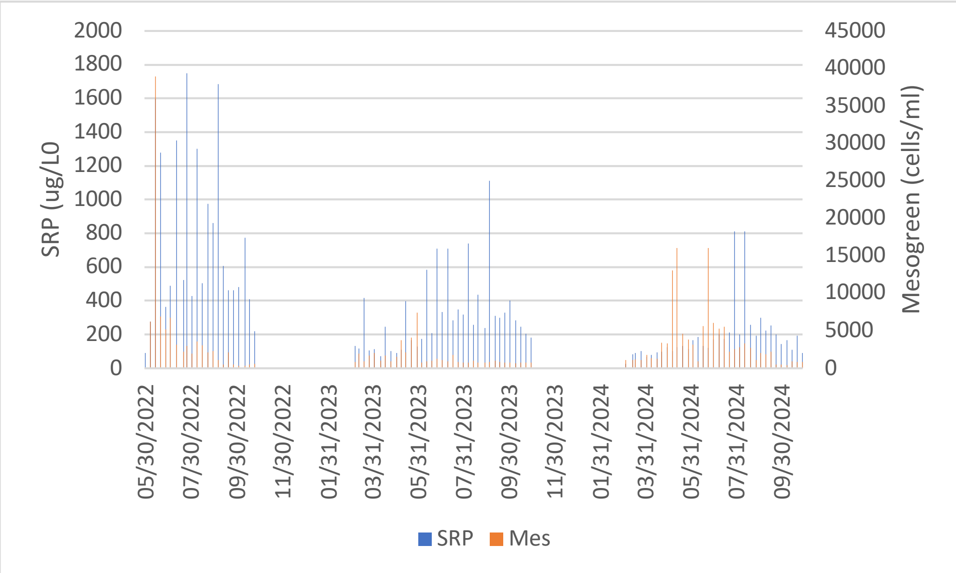


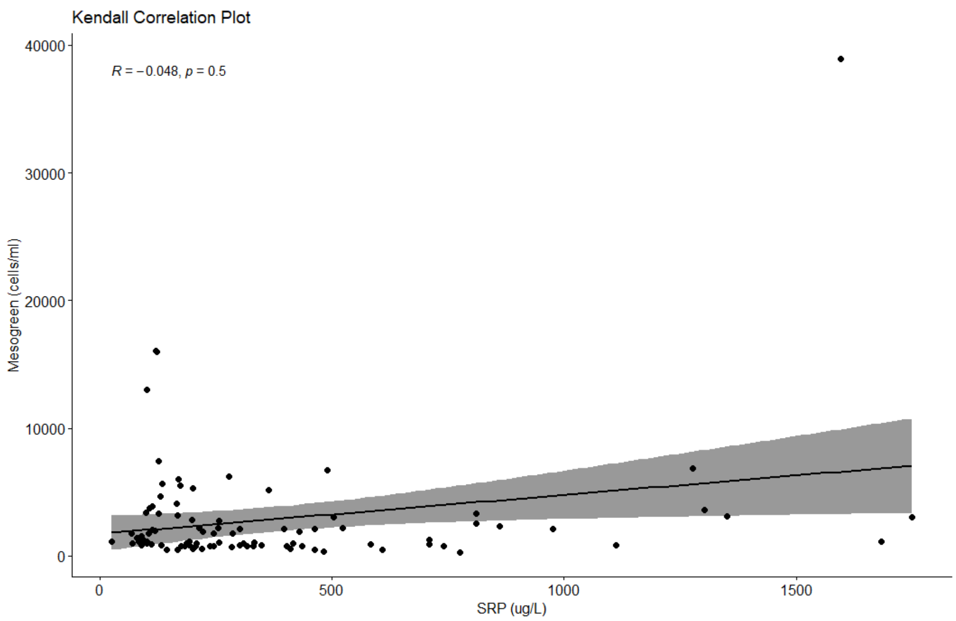
SRP – Meso-green algae

A.2.88 Meso-green algae numbers spiked during the spring of 2022, but such abundance was not recorded afterwards. The SRP concentrations were lower during 2023 and 2024 relative to that of 2022, which may have influenced the meso-green algae abundance. However, decreased meso-green algal growth was recorded during periods of SRP spikes during the summer of 2023 and 2024, suggesting SRP was not the limiting factor for diatom growth at this site.

A.2.89 The correlation between SRP concentrations and meso-green algal count was both insignificant (P>0.05) and extremely weak (tau <0.1), suggesting SRP alone did not determine the abundance of meso-green algae.

Plate A.26 A comparison between Mesogreen algae numbers and SRP concentrations (top) and correlation assessment between SRP concentrations and Mesogreen algae numbers (bottom) using Kendall's tau (Key: Strong correlation: tau =>0.3; moderate correlation: tau = 0.2 – 0.29; weak correlation: 0.1 – 0.19).





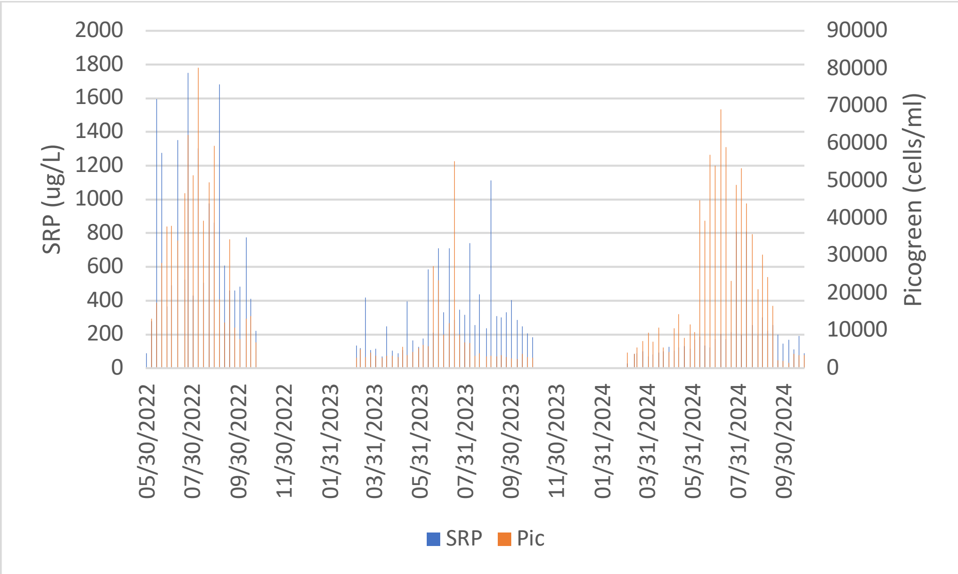
SRP – Pico-green algae

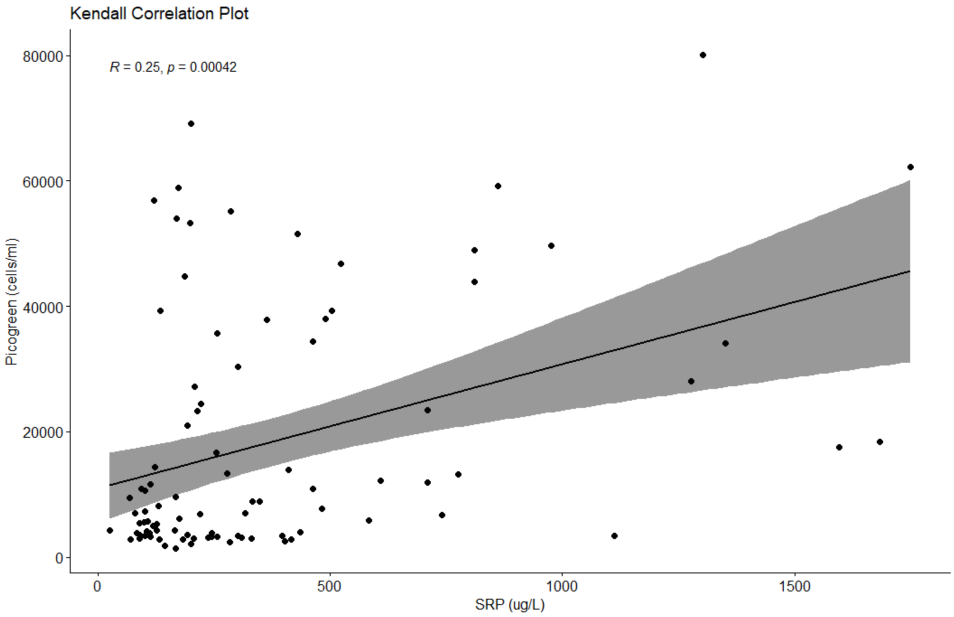
A.2.90 Pico-green algae numbers spiked over the sampling period but were lower during 2023 relative to those during 2022. However, despite relatively lower

SRP concentrations over the summer of 2024, pico-green abundance was higher than that during 2023 and equivalent to that during 2022. This suggests SRP is not the limiting factor for pico-green algae growth at this site.

A.2.91 A significantly negative ($P<0.001$) correlation was determined between SRP concentrations and pico-green algae count, with the correlation indicated to be a moderate correlation (tau = 0.25). The data suggests an increase in pico-green algae may occur concurrently with a decrease in SRP, indicating assimilation to be, at least in part, the reason for decreasing SRP concentrations.

Plate A.27 A comparison between Picogreen algae numbers and SRP concentrations (top) and correlation assessment between SRP concentrations and Picogreen algae numbers (bottom) using Kendall’s tau (Key: Strong correlation: tau =>0.3; moderate correlation: tau = 0.2 – 0.29; weak correlation: 0.1 – 0.19).





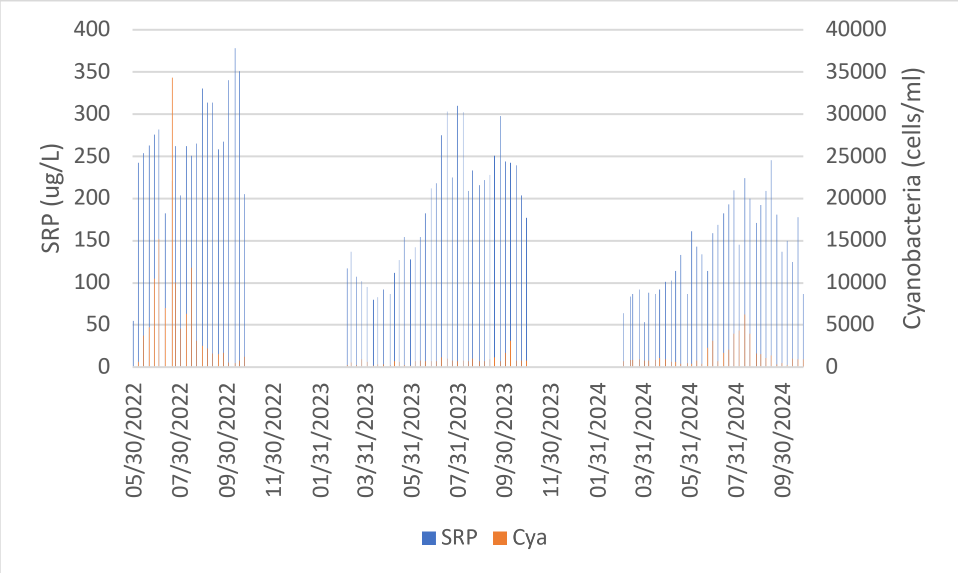
ATK27 Richmond Pound 1 (tidal River Thames)

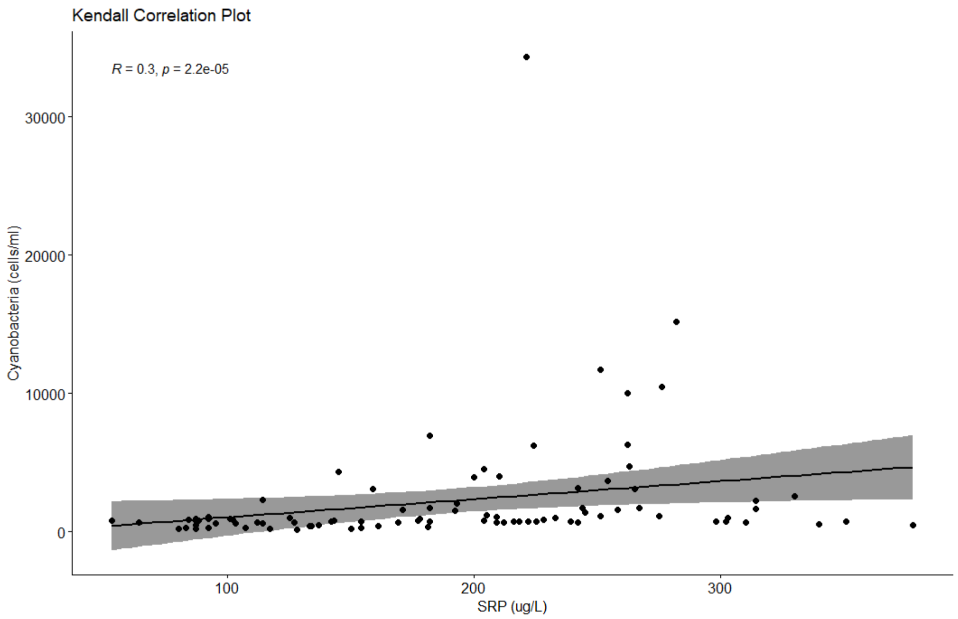
SRP - Cyanobacteria

A.2.92 Cyanobacterial numbers spiked during the summer period of 2022. SRP concentrations slightly decreased over the 2023 and 2024 summers, but cyanobacterial counts remained low, indicating the influence of other factors upon cyanobacterial abundance.

A.2.93 A significantly positive ($P<0.005$) correlation was determined between SRP concentrations and cyanobacterial count, with a strong (tau = 0.3) correlation.

Plate A.28 A comparison between Cyanobacterial numbers and SRP concentrations (top) and correlation assessment between SRP concentrations and Cyanobacterial numbers (bottom) using Kendall's tau (Key: Strong correlation: tau =>0.3; moderate correlation: tau = 0.2 – 0.29; weak correlation: 0.1 – 0.19).



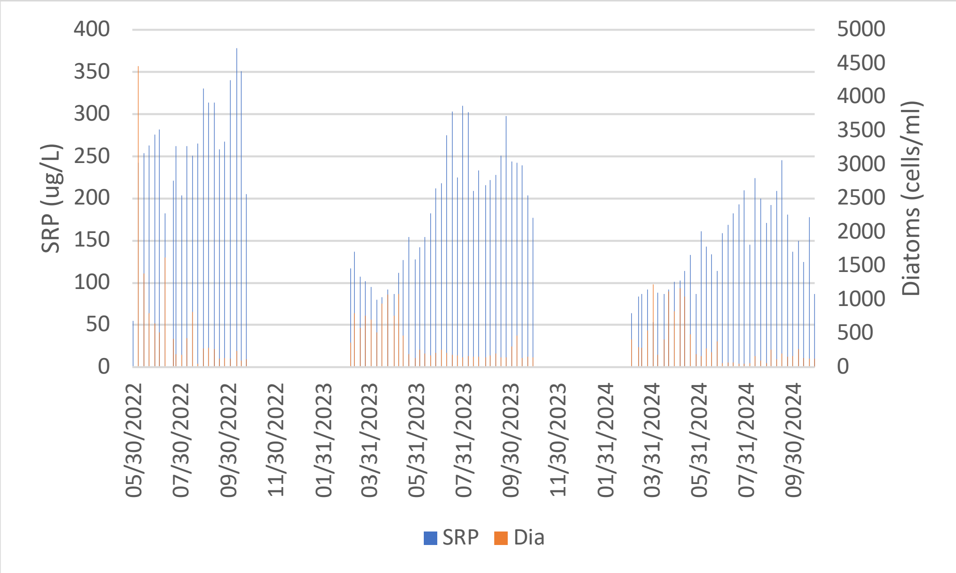


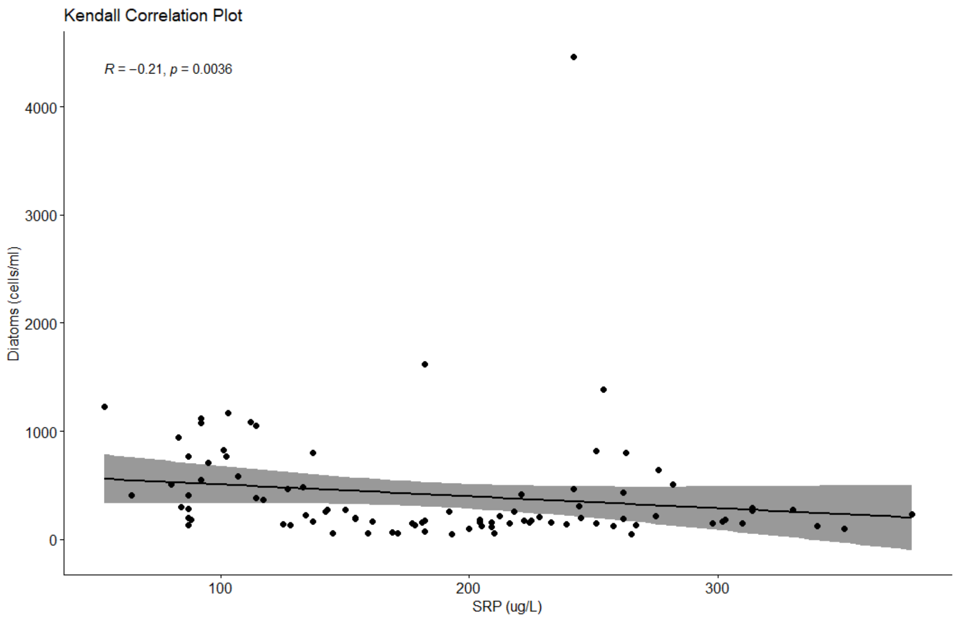
SRP - Diatoms

A.2.94 Diatom numbers spiked during 2022 but such abundance was not recorded afterwards despite concentrations of SRP only slightly decreasing relative to those of 2022 over the growing seasons (spring/summer and autumn). This suggests SRP was not the limiting factor for diatom growth at this site.

A.2.95 A significantly negative (P<0.005) correlation was determined between SRP concentrations and diatom count, with the correlation indicated to be a strong correlation (tau =-0.21). This may be influenced by a number of outliers identified during 2021.

Plate A.29 A comparison between Diatom numbers and SRP concentrations (top) and correlation assessment between SRP concentrations and Diatom numbers (bottom) using Kendall's tau (Key: Strong correlation: tau =>0.3; moderate correlation: tau = 0.2 – 0.29; weak correlation: 0.1 – 0.19).



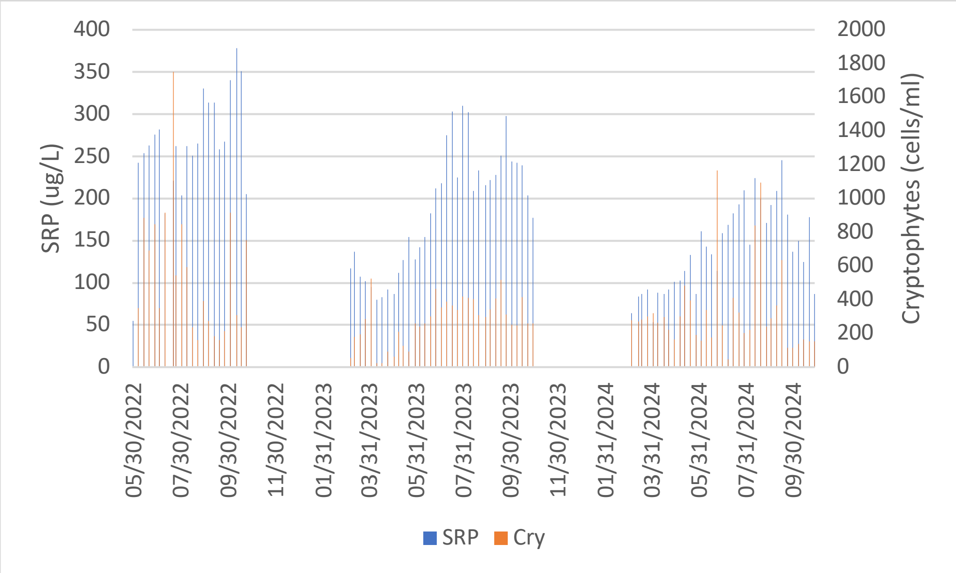


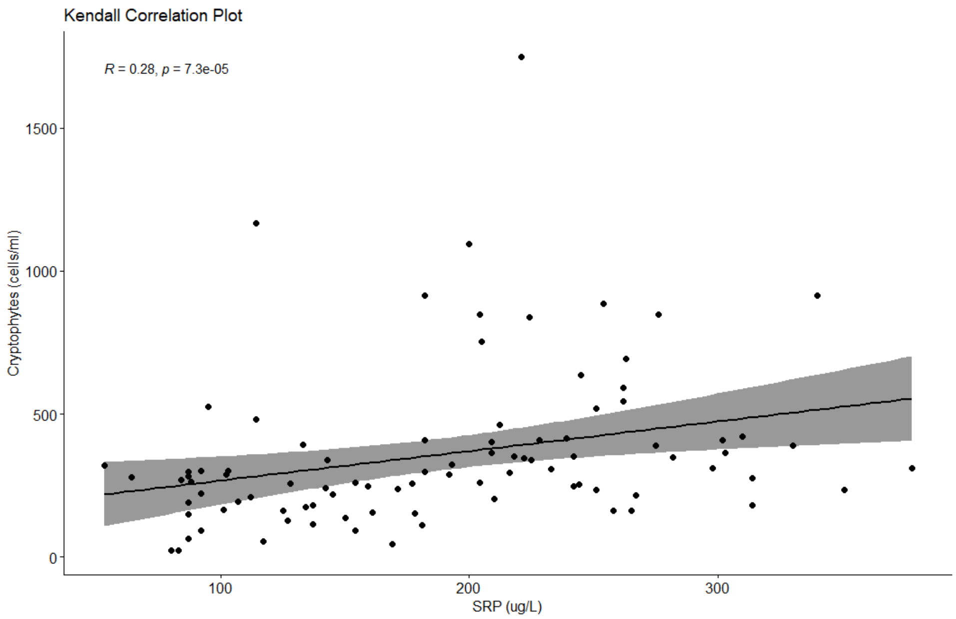
SRP - Cryptophytes

A.2.96 Cryptophyte numbers spiked during 2022 but despite not being as high as that over the growing season of 2022, peaks in growth were recorded over the growing seasons of 2023 and 2024. This suggests SRP was not the limiting factor for Cryptophyte growth at this site.

A.2.97 A significantly negative ($P<0.001$) correlation was determined between SRP concentrations and the Cryptophyte count, with the correlation indicated to be a strong correlation (tau =-0.28).

Plate A.30 A comparison between Cryptophyte numbers and SRP concentrations (top) and correlation assessment between SRP concentrations and Cryptophyte numbers (bottom) using Kendall's tau (Key: Strong correlation: tau =>0.3; moderate correlation: tau = 0.2 – 0.29; weak correlation: 0.1 – 0.19).



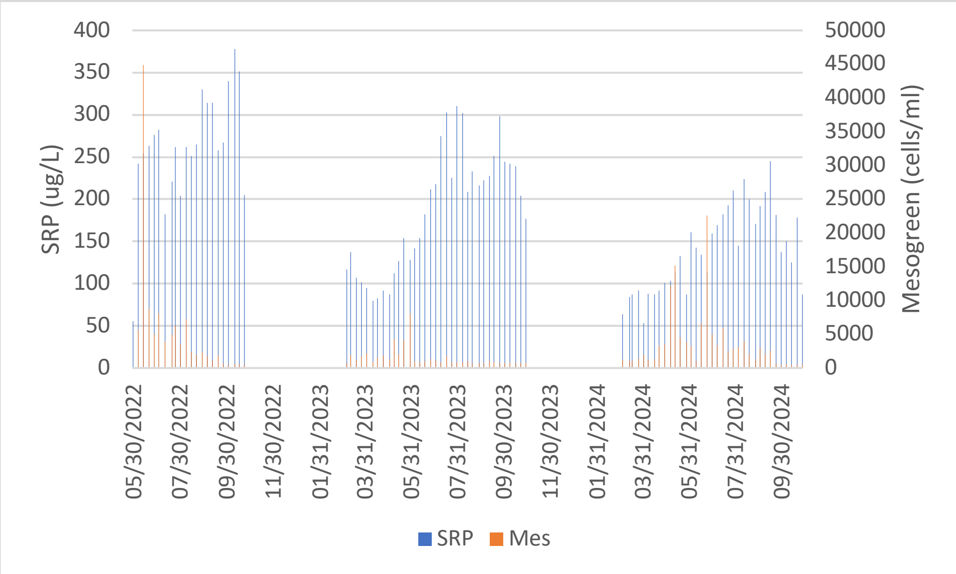


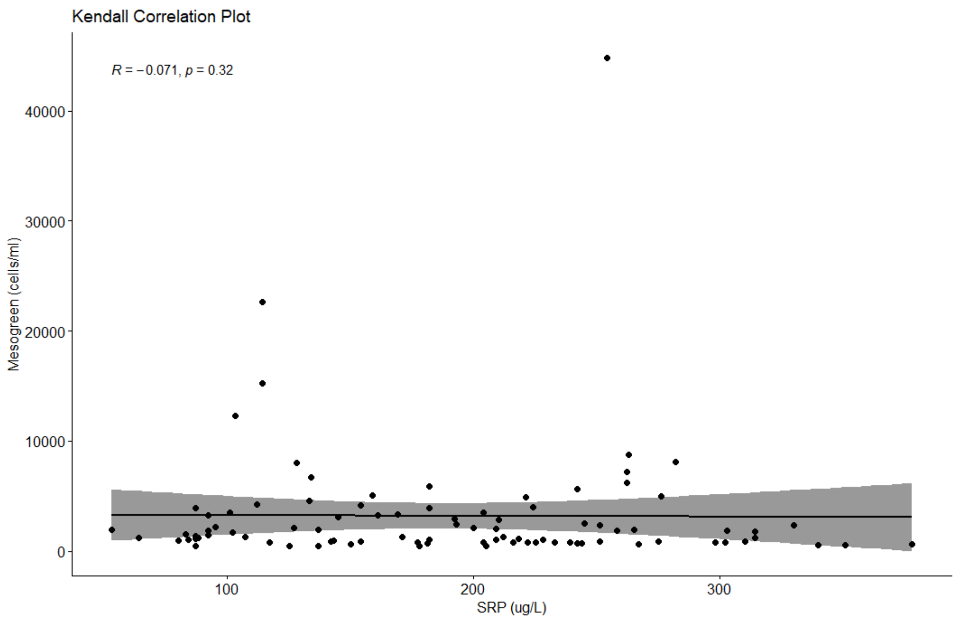
SRP – Meso-green algae

A.2.98 Meso-green algae numbers spiked during the spring of 2022, but such abundance was not recorded afterwards. The SRP concentrations were lower during 2023 and 2024 relative to that of 2022, which may have influenced the meso-green algae abundance. However, decreased meso-green algal growth was recorded during periods of SRP spikes during the summer of 2023 and 2024, suggesting SRP was not the limiting factor for diatom growth at this site.

A.2.99 The correlation between SRP concentrations and meso-green algal count was both insignificant (P>0.05) and extremely weak (tau <0.1), suggesting SRP alone did not determine the abundance of meso-green algae.

Plate A.31 A comparison between Mesogreen algae numbers and SRP concentrations (top) and correlation assessment between SRP concentrations and Mesogreen algae numbers (bottom) using Kendall's tau (Key: Strong correlation: tau =>0.3; moderate correlation: tau = 0.2 – 0.29; weak correlation: 0.1 – 0.19).



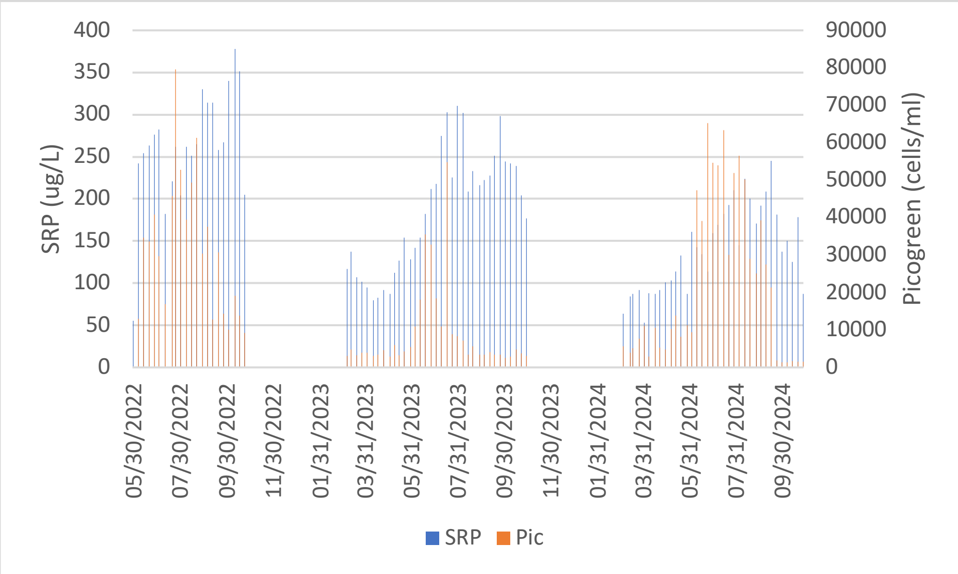


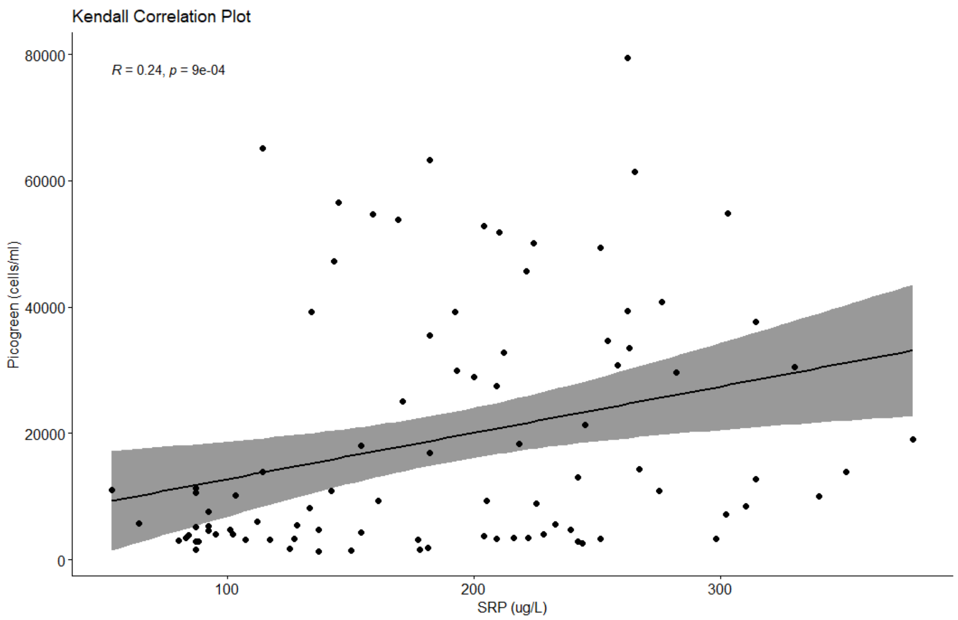
SRP – Pico-green algae

A.2.100 Pico-green algae numbers spiked and maintained a higher abundance over the sampling periods of 2022 and 2024 relative to that of 2023 despite relatively lower SRP concentrations over the summer of 2024 to 2023. This suggests SRP is not the limiting factor for pico-green algae growth at this site.

A.2.101 A significantly positive (P<0.001) correlation was determined between SRP concentrations and pico-green algae count, with the correlation indicated to be a moderate correlation (tau = 0.24). The data suggests an increase in pico-green algae may occur concurrently with a decrease in SRP, indicating assimilation to be at least in part, the reason for decreasing SRP concentrations.

Plate A.32 A comparison between Picogreen algae numbers and SRP concentrations (top) and correlation assessment between SRP concentrations and Picogreen algae numbers (bottom) using Kendall's tau (Key: Strong correlation: tau =>0.3; moderate correlation: tau = 0.2 – 0.29; weak correlation: 0.1 – 0.19).





Summary

A.2.102 Significant positive relationships between SRP and cyanobacteria levels were detected at Sites ATK5 and ATK7, ATK27 and ATK28, and between SRP and pico-green algae levels at ATK5, suggesting that SRP levels do influence phytoplankton growth at these sites. A negative relationship between SRP and meso-green algae was detected at Sites ATK5, ATK6 and ATK7.

A.2.103 Cyanobacterial growth at sites ATK 7 and ATK27 demonstrated a lower growth response during growing season of 2023 relative to previous and following years despite SRP concentrations being similar to that of previous years. Similarly, ATK28 recorded higher cyanobacterial abundance during 2024 relative to that of 2023, the latter which recorded a relatively higher overall concentrations of SRP. However, cyanobacterial growth at sites ATK5 and ATK6 followed the SRP concentrations more closely over the growing season (two growing seasons in total) relative to that at the other sites, with abundances decreasing possibly in response to seasonal changes (cooler conditions/shorter daylight hours), but this does not confirm SRP is or is not a limiting factor at these sites.

A.2.104 The algae at all five locations demonstrated varying seasonal growth patterns but none consistently maintained higher growth rates during periods of elevated SRP concentrations.

A.2.105 The algae and cyanobacteria sampled at the five locations (ATK27, ATK28, ATK5, ATK6 and ATK7) reacted to Soluble Reactive Phosphorus (SRP) availability but cell abundances frequently decreased despite a continuation of raised SRP concentrations during the growing season, suggesting SRP was not a limiting factor for the algae at the sites.

WFD assessment

A.2.106 Phytoplankton, although not generally monitored for WFD river classification, are part of the WFD classification for coastal and transitional waters (see Appendix 5.3) and are an important component of the freshwater and tidal River Thames aquatic ecosystems in the study area due in part to the large size of the river and the influence of water level control structures (for navigational purposes) on flows and level. This results in a deeper, slower-flowing environment favouring phytoplankton communities. These communities, along with detritus (and, to a lesser extent, macrophytes), are the predominant food sources for the aquatic communities associated with the freshwater and tidal River Thames in the study area.

A.2.107 Phytoplankton is not routinely monitored by the Environment Agency for WFD purposes in freshwater waterbodies. However, due to the importance of phytoplankton in the ecosystem of the freshwater Thames, project-specific data was collected for the freshwater Thames between 2021 and 2024. These samples were indicatively assessed following the UKTAG Transitional Water Assessment Method and the Transitional Water (TW) Phytoplankton Tool[7], considering Inner salinity zone (1-25ppm) threshold values as an approximation for phytoplankton values in freshwater sites. N.B. This assessment would not usually be used for freshwaters and the tool used was developed specifically for classification of transitional waters not freshwaters. It has been used here due to the proximity of the estuary and the pass forward of flow over Teddington weir, but the results must be treated with caution and are indicative only for the freshwater sites ATK5, ATK6 and ATK7.

[7] UKTAG Transitional Water Assessment Method, Phytoplankton, Transitional Water Phytoplankton Tool; ISBN: 978-1-906934- 41-5

A.2.108 The TW Phytoplankton Tool combines two indices: the chlorophyll multimetric and the elevated count multimetric. The chlorophyll multimetric evaluates chlorophyll biomass through mean, median, compliance under two thresholds, and exceedance over a maximum threshold across two salinity zones. The elevated count multimetric measures the frequency of phytoplankton count exceedances for single and total taxa thresholds. These indices are averaged to provide an overall assessment on an Environmental Quality Ratio (EQR) scale from 0 to 1.

A.2.109 In the absence of phytoplankton taxa identified at the species or genus level, taxonomic groups such as class or phylum can be used for the elevated count multimetric, especially when large-scale studies and significantly high number of samples make species or genus level identification not feasible within required timescales. Thus, this assessment considers the groups; Diatoms, green (pico) algae, green (meso) algae, Cryptophytes, and Cyanobacteria.

A.2.110 The EQR values for all five sites are classified by the WFD[8,9] into water quality standards (Table A.4). ATK27, ATK28 and ATK7 values indicate 'Moderate' ecological status, while ATK5 and ATK6 values correspond to 'Poor' ecological status as detailed in Table A.1.

Table A.4 Phytoplankton indicative EQR value at each sampling site and corresponding WFD water quality classification - Thames Tideway (Teddington Weir to Battersea)

Site	EQR	Ecological Status
ATK27	0.58	Moderate
ATK28	0.58	Moderate
ATK5	0.36	Poor*
ATK6	0.36	Poor*
ATK7	0.57	Moderate*

**Indicative score only – results are for a tool developed for transitional waters applied to freshwater sites.*

Phytobenthos (Diatoms)

A.2.111 This section covers benthic diatom communities specifically; planktonic diatoms are covered as part of the phytoplankton above. There were no diatom data available for the Thames Tideway (Thames Water Walton Intake to Battersea) as phytobenthos (diatoms) are not routinely used for WFD assessment in tidal waters as they are in freshwaters and are not, therefore, considered a receptor for the tidal River Thames. The baseline presented for this group is therefore limited to the freshwater River Thames. Table A.5 shows the full list of

[8] Department for Environment, Food & Rural Affairs. (2015). *The Water Framework Directive (Standards and Classification) Directions (England and Wales) 2015.* https://www.legislation.gov.uk/uksi/2015/1623/pdfs/uksiod_20151623_en_auto.pdf
[9] Water Framework Directive – United Kingdom Technical Advisory Group. (2013). *Final recommendations on biological standards.* Annex 19. Transitional Waters Phytoplankton. https://www.wfduk.org/sites/default/files/Media/UKTAG%20Final%20recommendations%20on%20biological%20stds_20131030.PDF

phytobenthos diatom site locations used to establish the baseline for the freshwater River Thames.

Table A.5 List of monitoring sites included in the phytobenthos diatoms baseline

Study Area	Site Name	NGR
Freshwater Thames	35861	TQ1701271462
	LRUS 004	TQ1529868498
	LRUS 005/ EA 35900	TQ1744067824
	LRUS 006	TQ1741471171

Freshwater Thames (Thames Water Walton Intake to Teddington Weir)

A.2.112 Diatom community data were based on eight surveys conducted between 2007 – 2010 by the Environment Agency (EA) and 15 samples conducted between 2021 - 2023 by Ricardo. Sampling locations can be found in Plate A.33.

A.2.113 The diatom community of the freshwater Thames consisted mostly of common diatom species, such as *Gomphonema* spp. and *Nitzschia* spp. that do not have specific habitat preferences. The more abundant taxa present have a preference for slower-flowing habitats and silt. These include *Fragilaria* spp., *Navicula* spp. and *Gyrosigma* spp.[10].

A.2.114 Total Trophic Diatom Index (TDI) using light microscopy (LM) scores ranged from 54.1 to 85.56. Mean TDI scores for each site were above 69, indicating high nutrient levels. Of the species assigned a TDI score, the majority had a TDI ≥ 3. Total TDI scores are presented in Plate A.34.

A.2.115 TDI ecological quality ratio (EQR) scores ranged from 0.30 (indicative of poor ecological status) to 0.94 (indicative of high ecological status) (EQR classifications are listed in Table A.6). Of the results collected between 2021 and 2023, the majority were indicative of moderate to good ecological status. LRUS 005/ EA Site 35900 was the exception to this, with two EQR scores during that time indicative of poor ecological status (Plate A.35). Results from Site 35861 were also indicative of poor ecological status a number of times between 2007 – 2014 but no recent monitoring was undertaken at this site, having been replaced in recent monitoring by LRUS 006/EA Site 188056.

[10] Belcher H. and Swale E. (1976) A beginer's guide to Freshwater Algae. Culture Centre of Algae and Protozoa. Natural Environment Research Council.

Table A.6 WFD diatom EQR classification boundaries

EQR Classifaciton	Survey EQR
High	>0.8
Good	0.6 - 0.8
Moderate	0.4 - 0.6
Poor	0.4 - 0.2
Bad	<0.2

Plate A.33 Freshwater benthic diatom monitoring locations

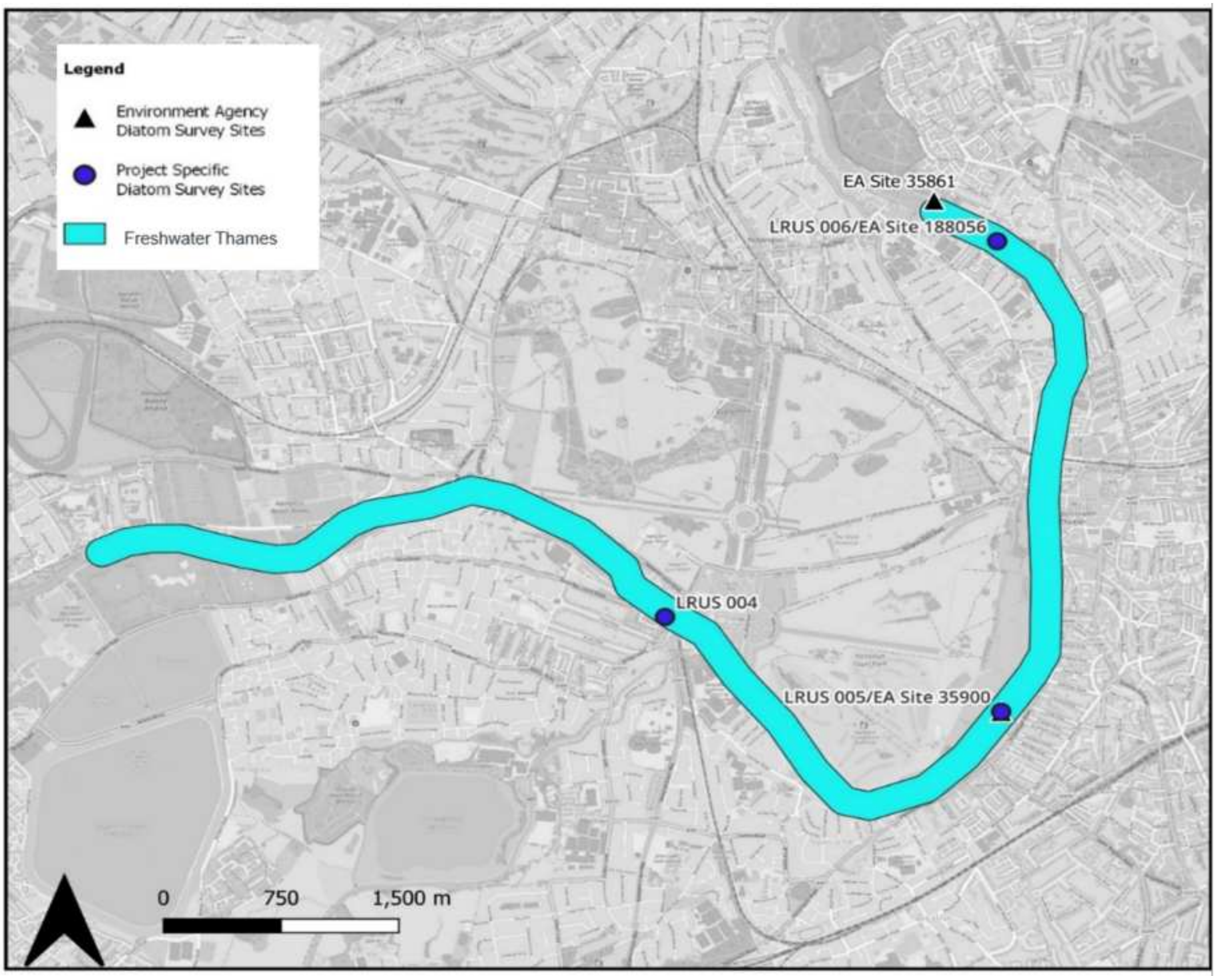


Table A.7 Diatom indices summary

Site ID	Site NGR	Survey count	Survey Range	TDI5LM Score Min - Max (AVG.)	TDI5LM Normalised EQR Min - Max (AVG.)	TDI5LM EQR Class Min - Max (AVG.) *B/P/M/G/H*	TDI5LM % PLANKTONIC Min - Max (AVG.)	TDI5 LM % MOTILE Min - Max (AVG.)	TDI5 LM % PTV Min - Max (AVG.)	TDI5 LM % SALINITY Min - Max (AVG.)
35861	TQ1701271462	6	2007 to 2014	69.35 - 85.56 (78.3)	0.3 - 0.63 (0.45)	P - G (M)	0 - 5.86 (1.69)	40.06 - 73.15 (58.22)	2.3 - 47.84 (23.43)	0 - 20.98 (5.92)
LRUS 004	TQ1529868498	5	2021 to 2023	64.7 - 71.34 (68.73)	0.59 - 0.73 (0.64)	M - G (G)	2.02 - 65.1 (23.37)	7.7 - 40.53 (26.06)	1.89 - 27.75 (8.69)	0.7 - 18.55 (4.63)
LRUS 005/ EA 35900	TQ1744067824	7	2010 to 2023	62.99 - 83.4 (74.07)	0.34 - 0.76 (0.53)	P - G (M)	0 - 28.55 (6.9)	6.8 - 44.85 (28.53)	0.53 - 23.45 (9.92)	0 - 2.06 (0.52)
LRUS 006	TQ1741471171	5	2021 to 2023	54.1 - 74.4 (69.25)	0.53 - 0.94 (0.63)	M - H (G)	0 - 13.27 (3.39)	21.39 - 70.85 (40.33)	5.61 - 32.29 (14.82)	0.52 - 1.38 (1.02)

Plate A.34 Trophic Diatom Index (TDI) scores

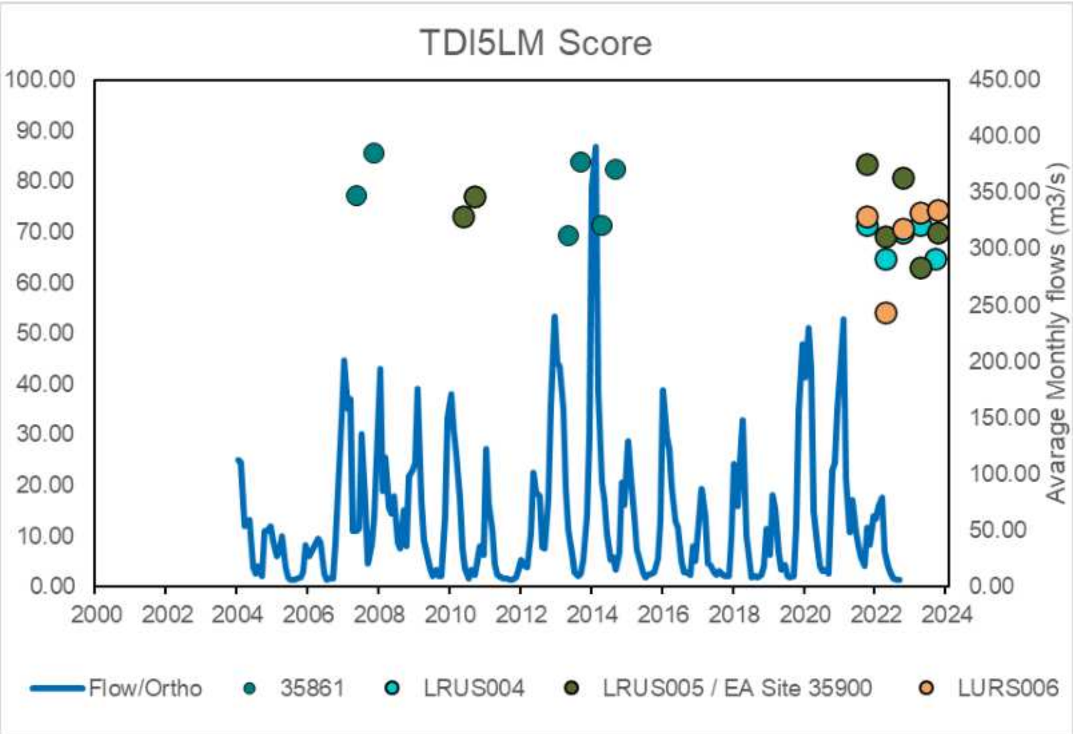
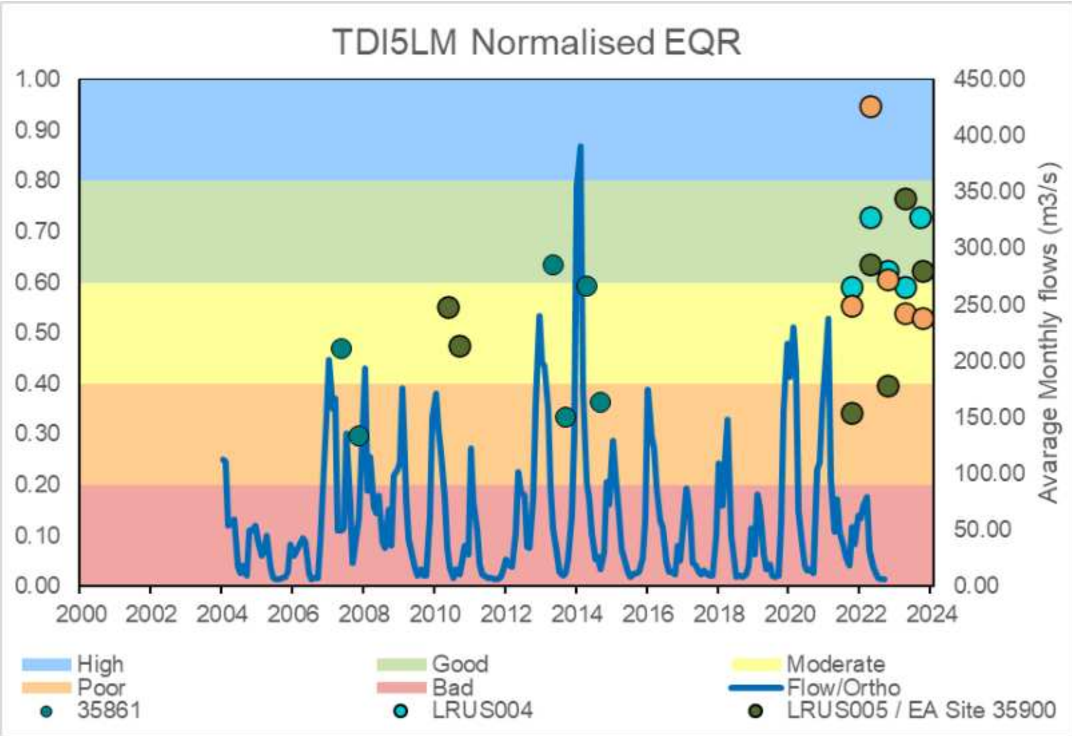
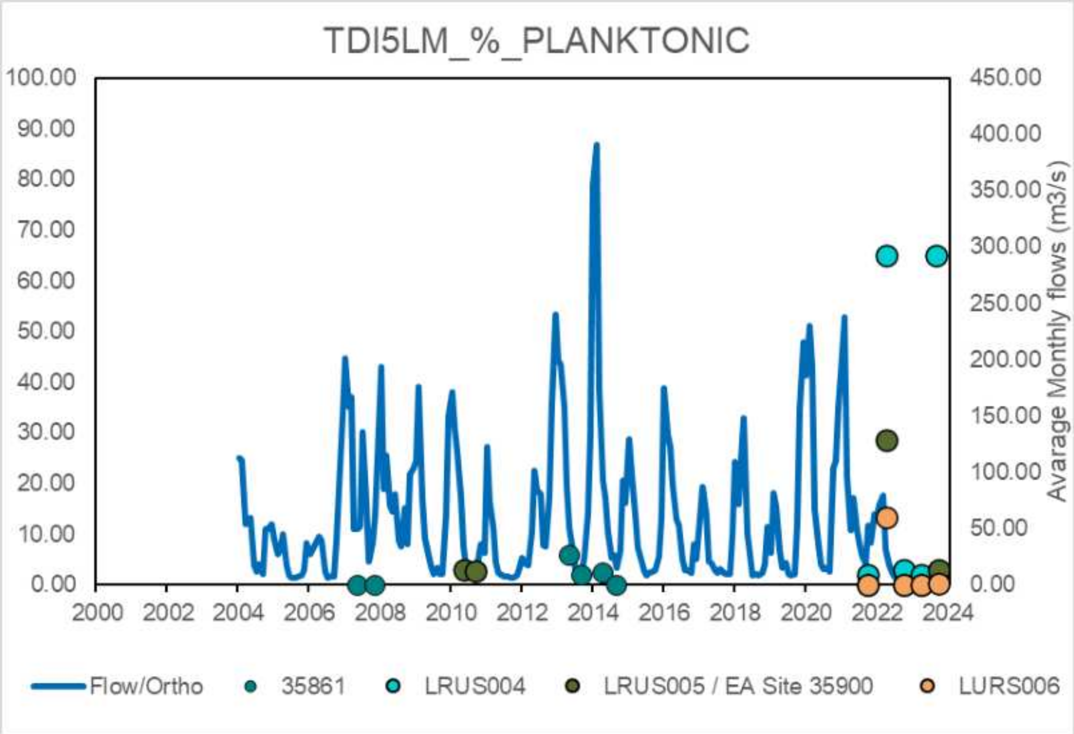


Plate A.35 Trophic Diatom Index (TDI) Ecological Quality Ratio (EQR) scores



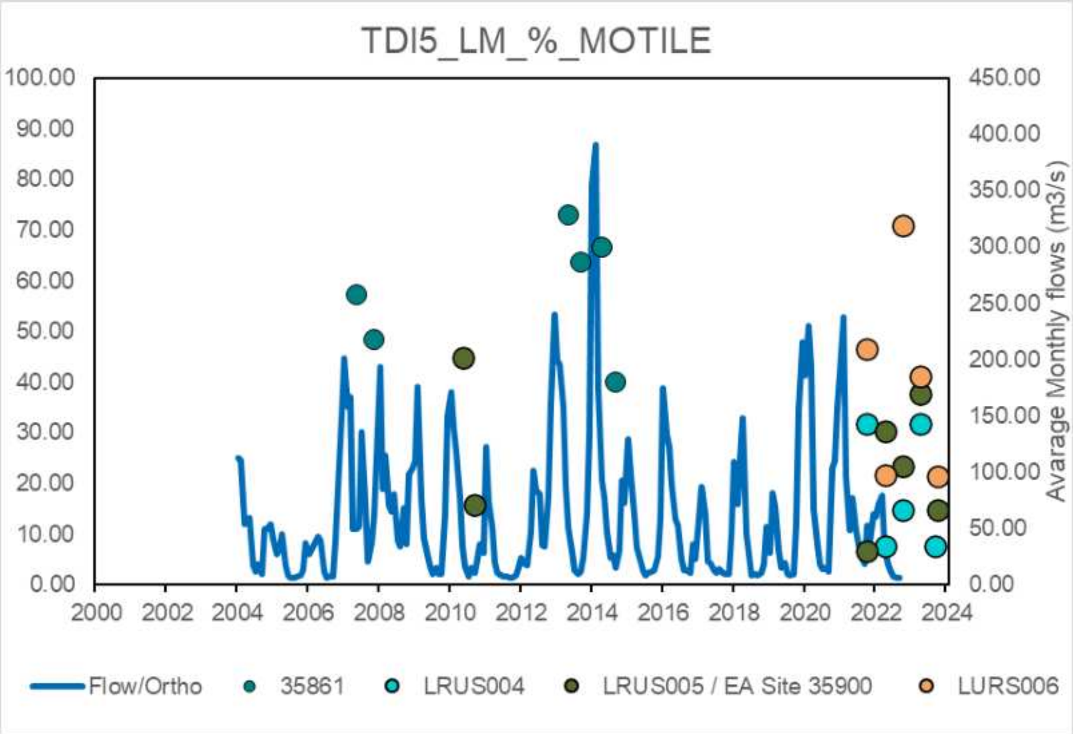
A.2.116 The percentage of planktonic diatoms for the majority of samples was low, except at LRUS 004 and LRUS 005/ EA Site 35900 in 2022 (Plate A.36). High percentages of planktonic diatoms would suggest that samples were taken from still or slow-flowing water.

Plate A.36 Percentage of planktonic diatoms in each sample



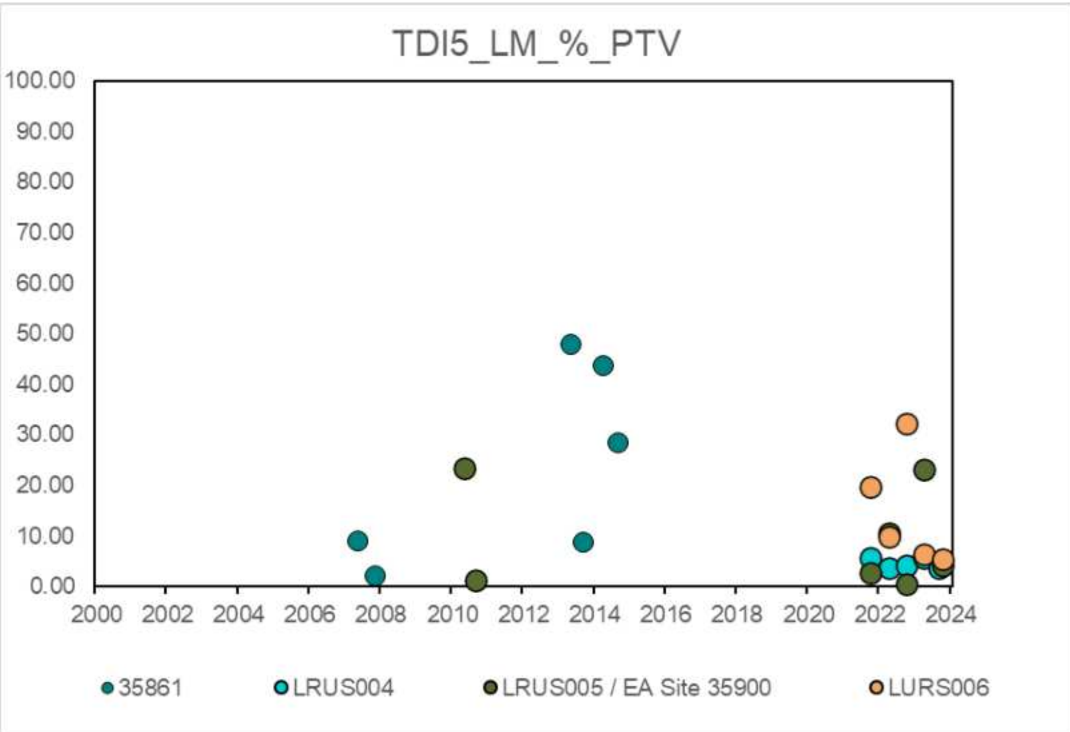
A.2.117 A higher percentage of motile diatom species suggests a high percentage of silt sediment is present within the watercourses. The percentage of motile species ranged from 6.8% – 73.15% (Plate A.37). The average percentage of motile species for each site was ≤23.37% (Table A.7), indicating that the sedimentation at the site is low.

Plate A.37 Percentage of motile diatoms in each sample



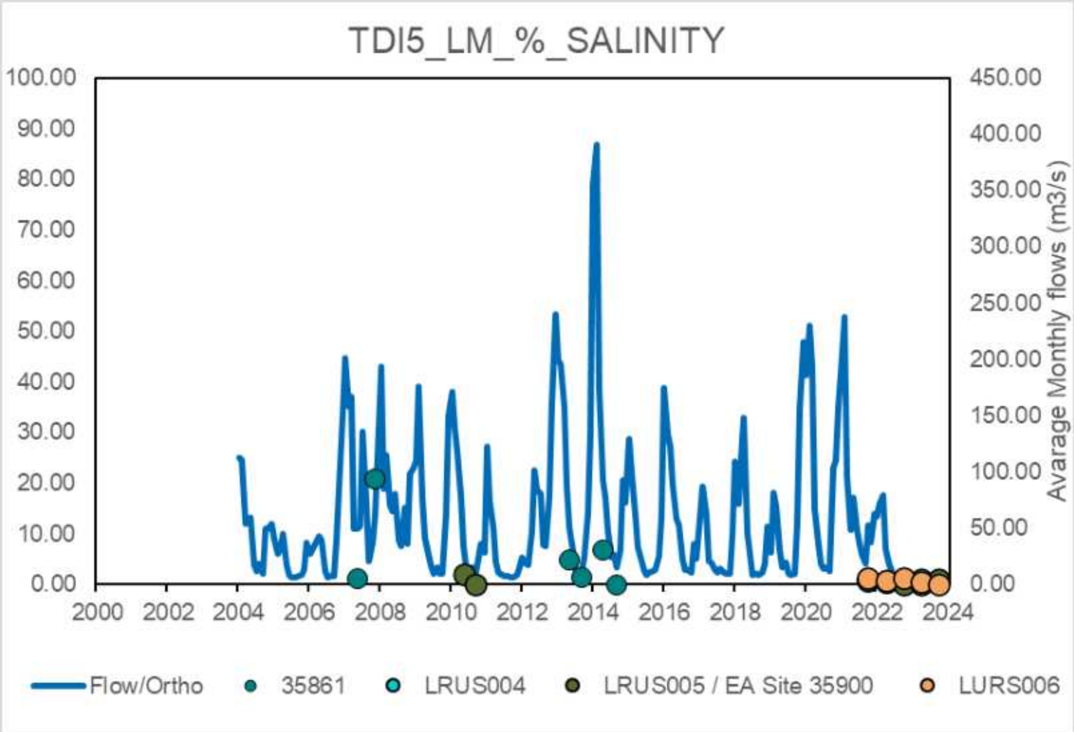
A.2.118 Pollution tolerance value (PTV) percentages ranged from 0.53% to 47.84% (Plate A.38). The average percentage of organic pollution-tolerant species for each site was ≤23.43% for all the sites (Table A.7). This does not indicate high levels of nutrient enrichment.

Plate A.38 Percentage of pollution tolerant diatoms (pollution tolerance value (PTV) in each sample



A.2.119 The percentage of saline-tolerant diatom species was low for the majority of samples, with the exception of LRUS 004 in 2023 which was 18.55% and at 35861 in 2007 which was 20.93%. This suggests there is limited saline influence on the diatom community at these sites (Plate A.39).

Plate A.39 Percentage of diatom taxa tolerant of high salinity in each sample



Macrophytes and Macroalgae

A.2.120 Macrophytes are freshwater aquatic plants visible to the naked eye and may grow emergent, submerged, floating or amphibiously. The group includes flowering plants, bryophytes and filamentous or encrusting algal species forming macroscopic colonies or filaments. Macroalgae are the group of organised macroscopic algae often referred to as sea weeds, but can also include filamentous algae growing in tidal areas.

A.2.121 Table A.8 shows the full list of macrophytes site locations used to establish the baseline for the freshwater and Thames Tideway. Baseline methodology and data for the LEAFPACS monitoring is presented in the Aquatic Ecology Consolidated Report[11]

Table A.8 List of phytoplankton survey site locations

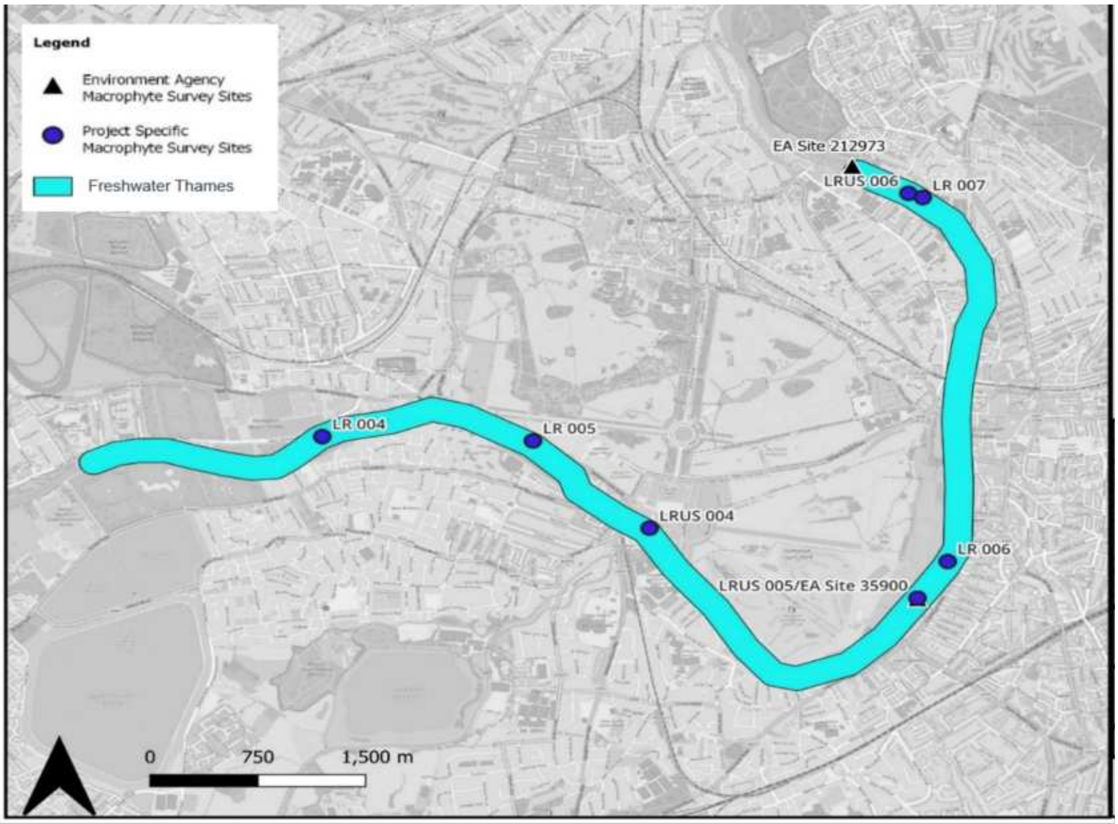
Study Area	Site Name	NGR
Freshwater Thames	LR 04	TQ1330069172

[11] Thames Water Utilities Ltd (2024) Aquatic and Estuarine Ecology Baseline Consolidated Report. Document No J698-AJ-C02B-TEDD-RP-EN-100002

Study Area	Site Name	NGR
	LR 05	TQ1476569136
	LR 06	TQ1765068130
	LR 07	TQ1747671167
	LRUS 004	TQ1557668408
	LRUS 005/EA 35900	TQ1744067824
	LRUS 006	TQ1737771202
	Burnell Outfall Survey	TQ16777153 - TQ17437116
Estuarine Thames	212973	TQ1681671534
	Isleworth A	TQ16767601
	Isleworth B	TQ16657583
	Isleworth C	TQ16657570

A.2.122 Macrophyte community data is based on seven sites located between the Thames Water Walton intake and Teddington Weir. Ricardo sampled all seven of the sites in 2023. The standard WFD LEAFPACS methodology was used to survey a 100 m stretch at each site. Four of the sites were sampled by Jacobs in 2020, and one of the sites was sampled by the EA four times between 2007 and 2023. Monitoring locations can be found in Plate A.40.

Plate A.40 Freshwater macrophyte monitoring locations



A.2.123 Along the freshwater Thames (Thames Water Walton Intake to Teddington Weir), the bank profile tends to be modified, with many areas of artificial concrete banks, bank profiles that are steep/ vertical, and a modified channel profile that leaves only small areas of marginal habitat for macrophytes to colonise. Where suitable habitat is available, the bankside vegetation along the Thames consists of stands of alder (*Alnus glutinosa*) and willow species (*Salix* sp.). Small areas of marginal aquatic species are present. Species include water mint (*Mentha aquatica*), gypseywort (*Lycopus europaeus*), yellow iris (*Iris pseudacorus*) and purple loosestrife (*Lythrum salicaria*).

A.2.124 The in-channel macrophyte community consists largely of macrophytes with a preference for deep, slow-flowing water bodies. Species include yellow water lily (*Nuphar lutea*), unbranched bur-reed (*Sparganium emersum*), hornwort (*Ceratophyllum demersum*), arrowhead (*Sagittaria sagittifolia*), and the INNS Nuttall’s waterweed (*Elodea nuttallii*). Green filamentous algae (*Cladophora glomerata/Rhizoclonium hieroglyphicum*) and mosses like greater water-moss (*Fontinalis antipyretica)* and fountain pocket-moss (*Octodiceras fontanum*) (often associated with concrete structures) are frequent.

A.2.125 River Macrophyte Nutrient Index (RMNI) from all the available data was indicative of a community with a high tolerance for nutrients. RMNI ranged from 6.89 to 8.87 RMNI ecological quality ratio (EQR) scores suggest that nutrient levels at the sites were slightly elevated, which would be expected for the Thames. The exceptions to this are RMNI scores from LR 06 in 2020, LRUS

004 in 2023 and LRUS 005/EA 35900 in 2007 and 2014, which were all equal to or lower than the expected scores for the sites (Plate A.41).

A.2.126 Macrophyte number of scoring taxa (NTAXA) ranged from 5 – 16 (Table A.9). Ten out of the fifteen surveys had NTAXA EQR scores which were higher than the predicted values for the sites (Plate A.42). Eleven out of the fifteen surveys had a higher number of functional groups (NFG) than expected for the sites (Plate A.44). This suggests that these sites on the Thames are more diverse than expected.

Table A.9 Macrophyte observed and expected indices summary for the Freshwater Thames

Site ID	Site NGR	Survey count	Survey Range	RMHI score Min - Max (AVG.)	RMNI score Min - Max (AVG.)	RMNI EQR Min - Max (AVG.)	NTAXA Min - Max (AVG.)	NTAXA EQR Min - Max (AVG.)	NFG score Min - Max (AVG.)	NFG EQR Min - Max (AVG.)	ALG (% cover) Min - Max (AVG.)	ALG EQR Min - Max (AVG.)	Survey EQR score Min - Max (AVG.)	Survey EQR Class Min - Max (AVG.) *B/P/M/G/H*
LR 04	TQ 13300 69172	2	2020 to 2023	0	8.53 - 8.58 (8.56)	0.47 - 0.5 (0.49)	8 - 10 (9)	0.81 - 1.02 (0.91)	5 - 7 (6)	0.77 - 1.02 (0.89)	0.1 - 1.75 (0.93)	0.86 - 1 (0.93)	0.47 - 0.5 (0.49)	M - M (M)
LR 05	TQ 14765 69136	2	2020 to 2023	0	8.08 - 8.12 (8.1)	0.71 - 0.73 (0.72)	7 - 10 (9)	0.71 - 1.02 (0.86)	5 - 9 (7)	0.66 - 1.02 (0.84)	0.05	1	0.7 - 0.71 (0.7)	G - G (G)
LR 06	TQ 17650 68130	2	2020 to 2023	0	6.89 - 8.22 (7.56)	0.59 - 1.29 (0.94)	5 - 14 (10)	0.56 - 1.56 (1.06)	4 - 9 (7)	0.48 - 1.66 (1.07)	0.05 - 0.5 (0.28)	0.96 - 1 (0.98)	0.59 - 0.99 (0.79)	M - H (G)
LR 07	TQ 17476 71167	2	2020 to 2023	0	7.96 - 8.06 (8.01)	0.74 - 0.8 (0.77)	8 - 9 (9)	0.81 - 0.91 (0.86)	6 - 8 (7)	0.78 - 0.9 (0.84)	0 - 0.05 (0.03)	1 - 1 (1)	0.74 - 0.8 (0.77)	G - G (G)
LRUS 004	TQ 15576 68408	1	2023	0	7.58	1	10	1.02	9	1.02	0.05	1	1	H
LRUS 005/EA 35900	TQ 17440 67824	5	2023 to 2017	0 - 7.85 (6.06)	7.27 - 8.28 (7.73)	0.6 - 1.16 (0.9)	6 - 16 (12)	0.61 - 1.61 (1.26)	5 - 11 (9)	0.54 - 1.72 (1.3)	0.05 - 37.55 (7.82)	0.2 - 1 (0.82)	0.4 - 1.06 (0.81)	M - H (H)
LRUS 006	TQ 17377 71202	1	2023	0	8.14	0.7	14	1.42	12	1.5	2.2	0.83	0.7	G

Plate A.41 Macrophyte RMNI EQR scores and raw scores

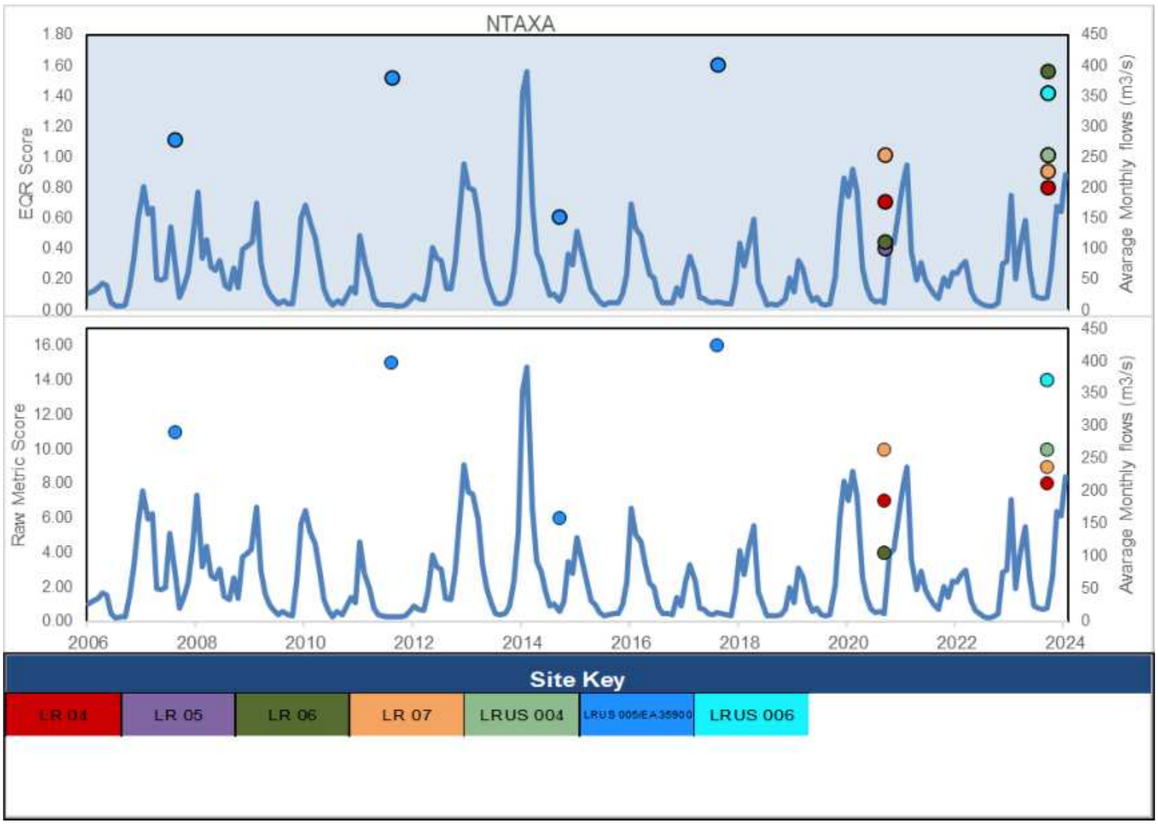


Plate A.42 Macrophyte NTAXA EQR indices and raw scores

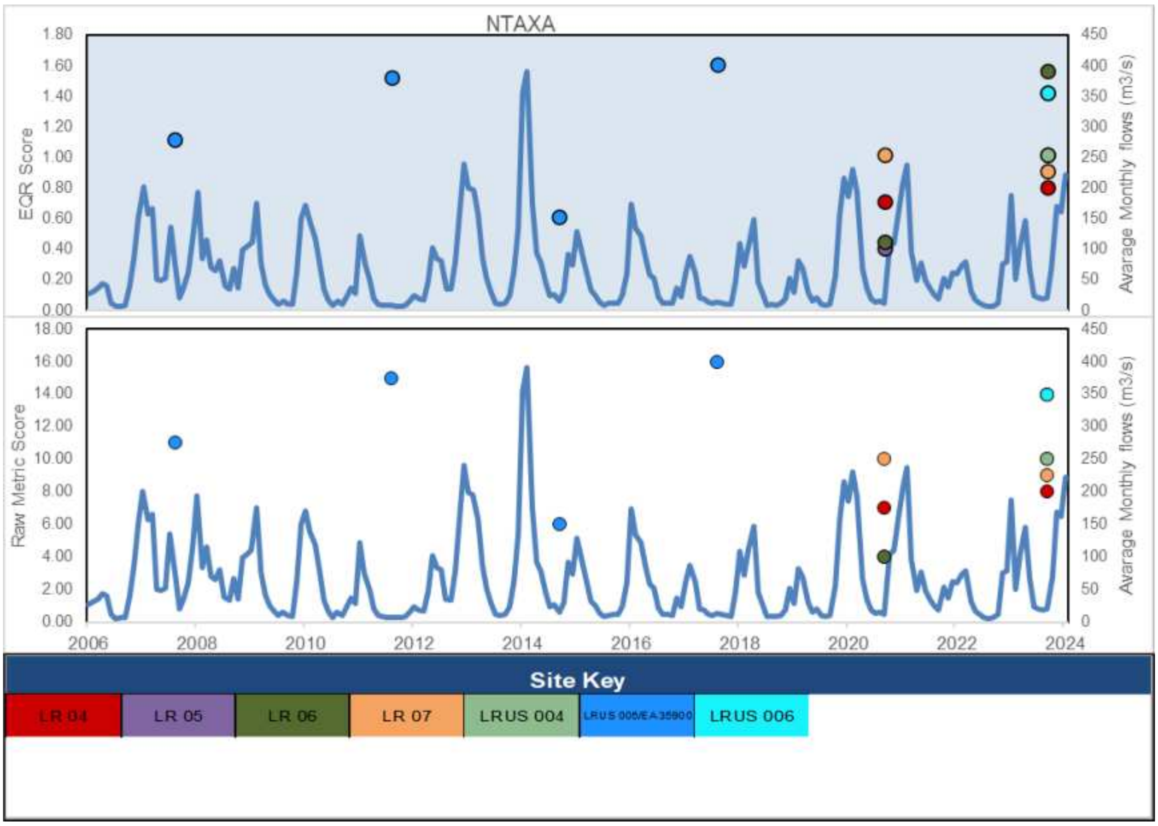
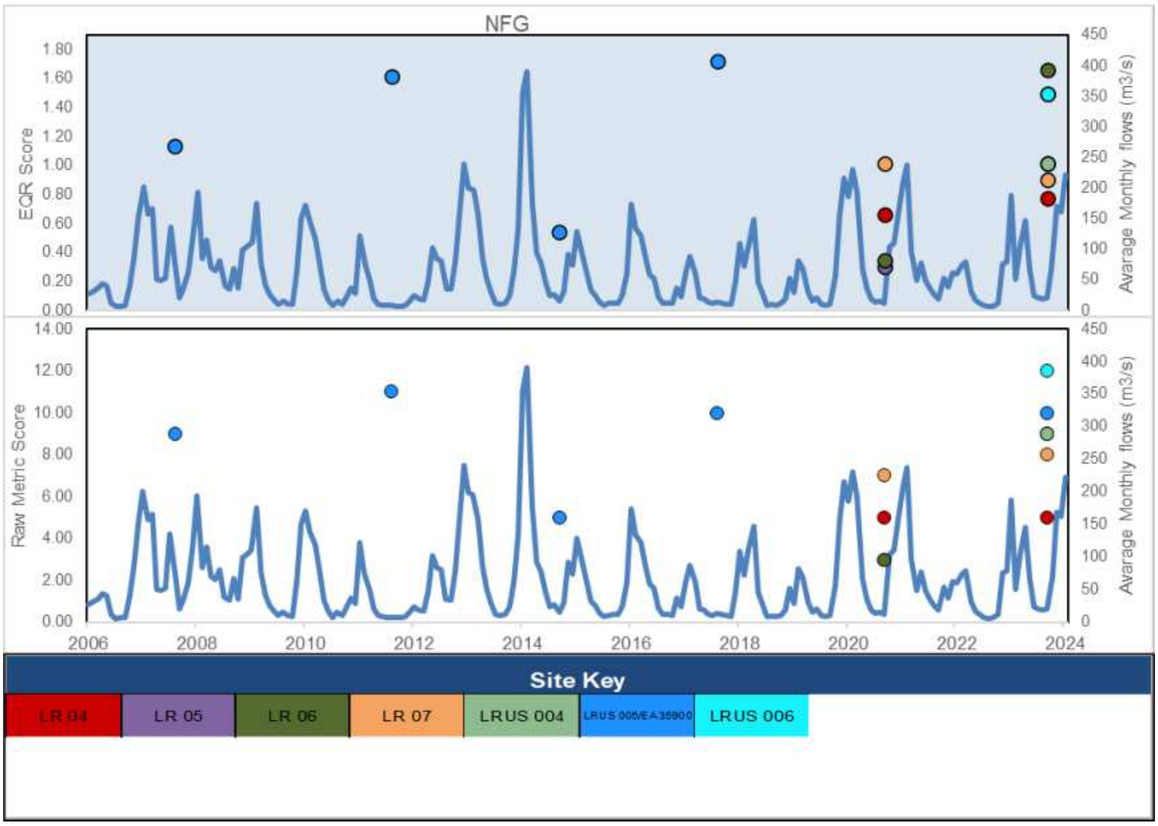
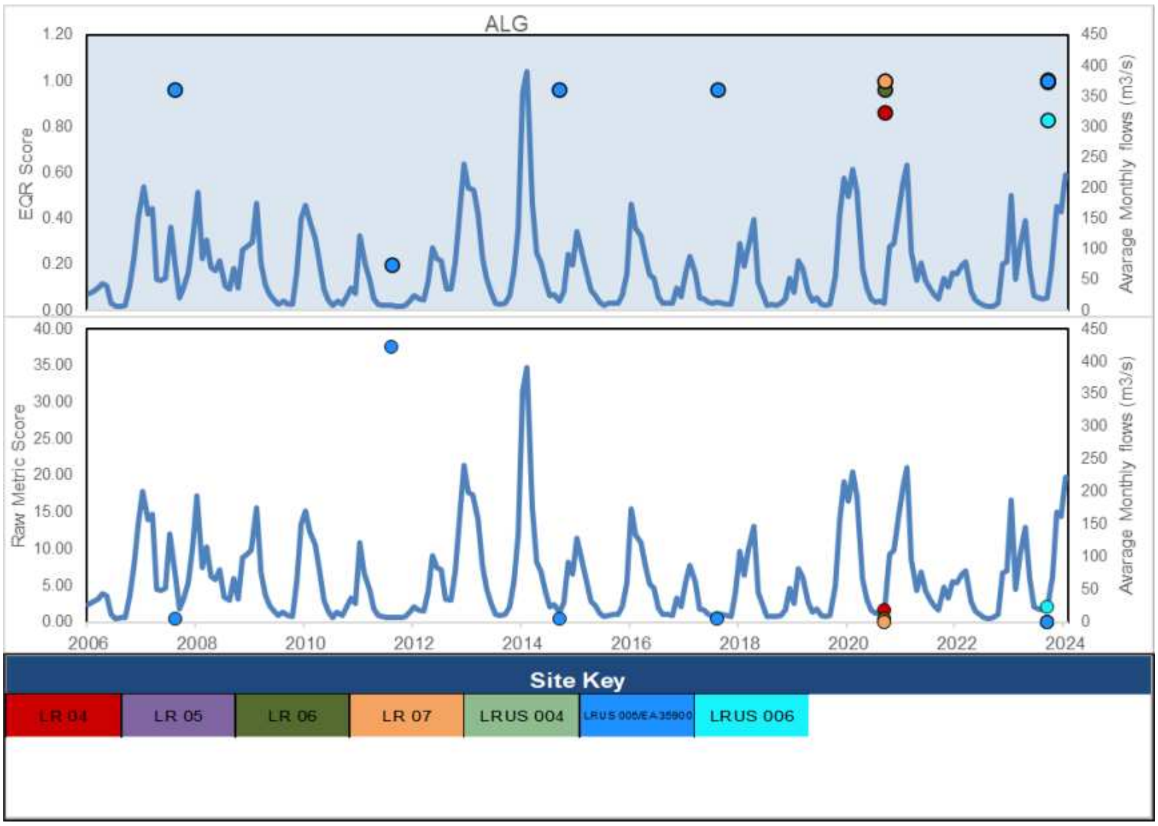


Plate A.43 Macrophyte NFG EQR indices and raw scores



A.2.127 The coverage of green filamentous algae (ALG) was low in the majority of surveys. The only exception to this was at LRUS 005/EA 35900 in 2011, where ALG was 37.55. During this survey, there was a high percentage of cover (between 25-50%) of the green filamentous algae *Cladophora glomerata/Rhizoclonium hieroglyphicum.*

Plate A.44 Macrophyte ALG EQR indices and raw scores

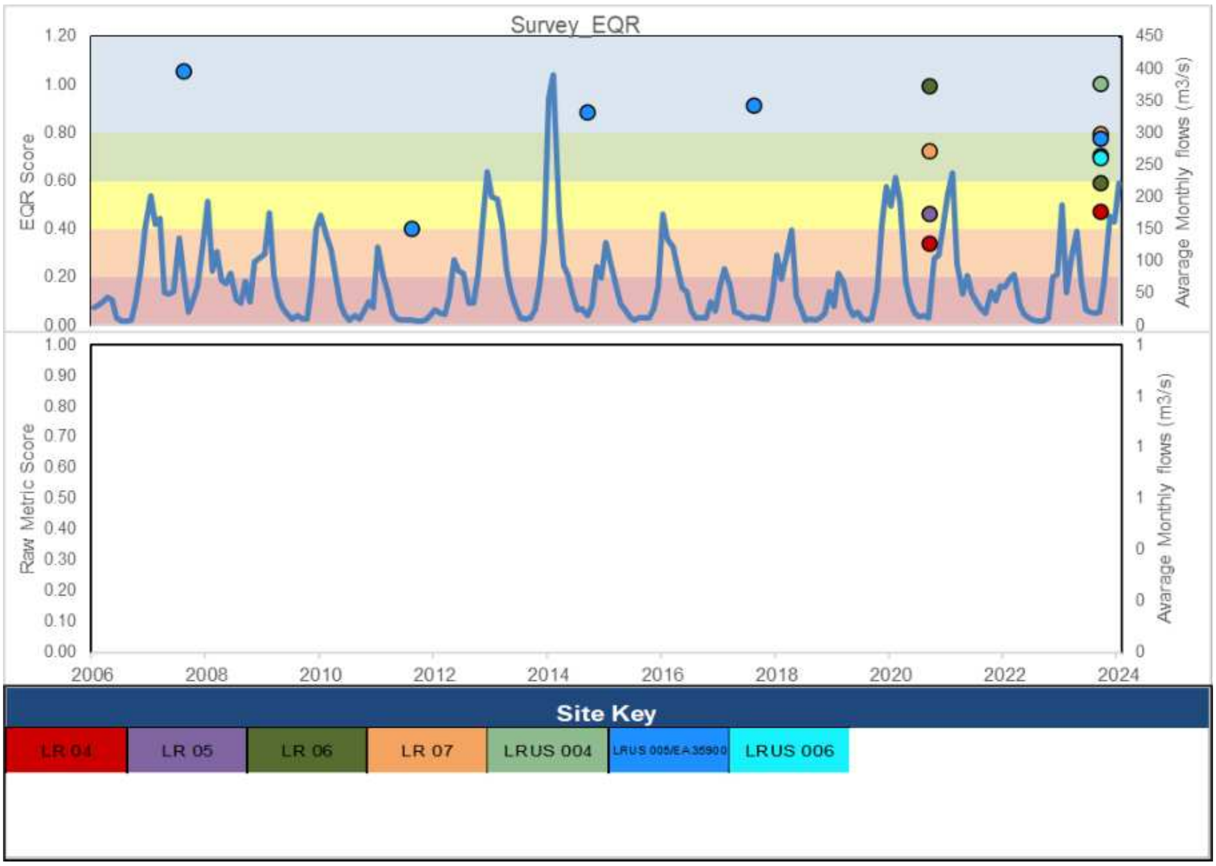


A.2.128 Overall survey EQRs for macrophytes ranged from 0.34 (indicative of Poor ecological status) to 1.06 (indicative of High ecological status) (Table A.9 and Plate A.45). These scores are variable, with five out of the fifteen survey being indicative of Poor or Moderate ecological status which would suggest the plant community was impacted by eutrophication. All other surveys were indicative of Good or High ecological status and the average EQR for all of the surveys was 0.75, which is indicative of good ecological status for macrophytes (see Table A.10 for classification boundaries).

Table A.10 WFD macrophyte EQR classification boundaries

EQR Classifaciton	Survey EQR
High	>0.8
Good	0.6 - 0.8
Moderate	0.4 - 0.6
Poor	0.4 - 0.2
Bad	<0.2

Plate A.45 Macrophyte overall survey EQRs



A.2.129 One designated species was recorded from the surveys on the Thames (Table A.40). This was flat-stalked pondweed (*Potamogeton friesii*).

A.2.130 Eight INNS were identified during the surveys and are listed in Table A.41 and Table A.42. These INNS were sweet flag (*Acorus calamus*), water fern (*Azolla filiculoides*), Canadian waterweed (*Elodea canadensis*), Nuttall's waterweed (*Elodea nuttallii*), giant rhubarb (*Gunnera tinctoria*), floating pennywort (*Hydrocotyle ranunculoides*), orange balsam (*Impatiens capensis*) and least duckweed (*Lemna minuta*).

Burnell Outfall survey

A.2.131 In August 2024, a bespoke macrophyte survey was conducted to assess the available habitat for juvenile fish and eels around the proposed outfall location at the Burnell site. Survey was undertaken by boat, using a bathyscope, underwater camera, and grapnel to identify and map the location of in channel and riparian macrophyte species and habitat features directly onto GIS basemaps using an adapted River Corridor Survey methodology[12]. Survey was undertaken from above the site of the intake to the lock channel downstream of Teddington weir but above Teddington Lock. The results of this survey are shown in Plate A.46 - Plate A.49 and in Table A.11.

[12] National Rivers Authority (1992) River Corridor Survey Manual. Technical handbook.

A.2.132 Aquatic vegetation around Teddington Weir was sparse, with only some very small areas of unbranched bur-reed (*Sparganium emersum*) present. A large area of diverse marginal species was present, growing on top of the barrier for the weir. Along the rest of the survey reach between Teddington Weir and Trowlock Island, on the right-hand bank, there were semi-continuous beds of macrophytes, approximately 5m wide, dominated by spiked water-milfoil (*Myriophyllum spicatum)*. The bank profile on this side of the river was either vertical/ artificial around the boat moorings present or steep/sloped with trees and some riparian species. Cobbles, boulders and silt were recorded here.

A.2.133 Along the left-hand bank, there was unbranched bur-reed around the weir and then a large area along some boat moorings where no macrophytes were recorded. A large macrophyte bed was recorded upstream of the Lensbury Hotel and Watersports Centre slipway. Unbranched bur-reed was the dominant species, but there were a number of species recorded which were not recorded on the right-hand bank including horned pondweed (*Zannichellia palustris),* hornwort (*Ceratophyllum demersum)* and arrowhead (*Sagittaria sagittifolia).* The bank profile along the whole left-hand bank was vertical/artificial. It was thought that the artificial nature of the banks and channel, as well as the heavy boat traffic in the area, were limiting factors for the growth of macrophytes in this area.

Plate A.46 Macrophyte mapping around Teddington Weir

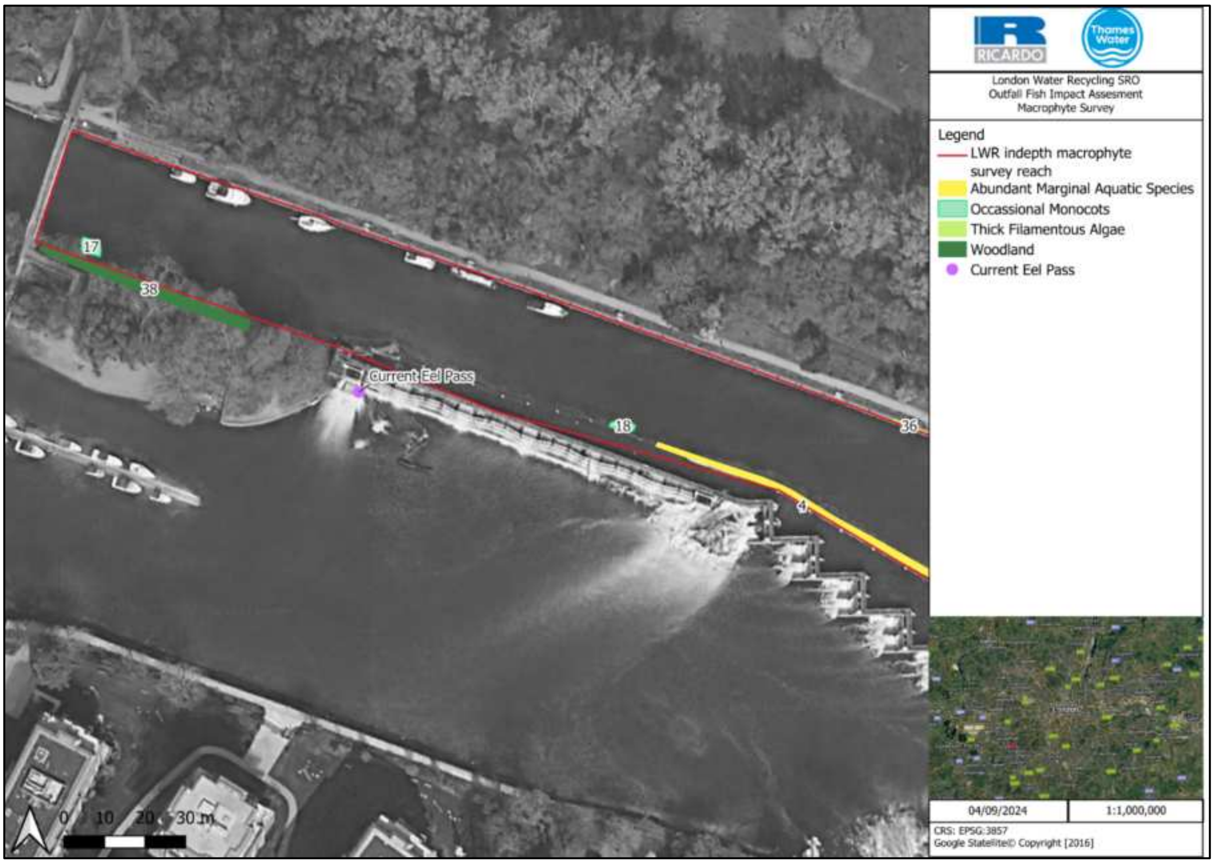


Plate A.47 Macrophyte mapping upstream of Teddington Weir

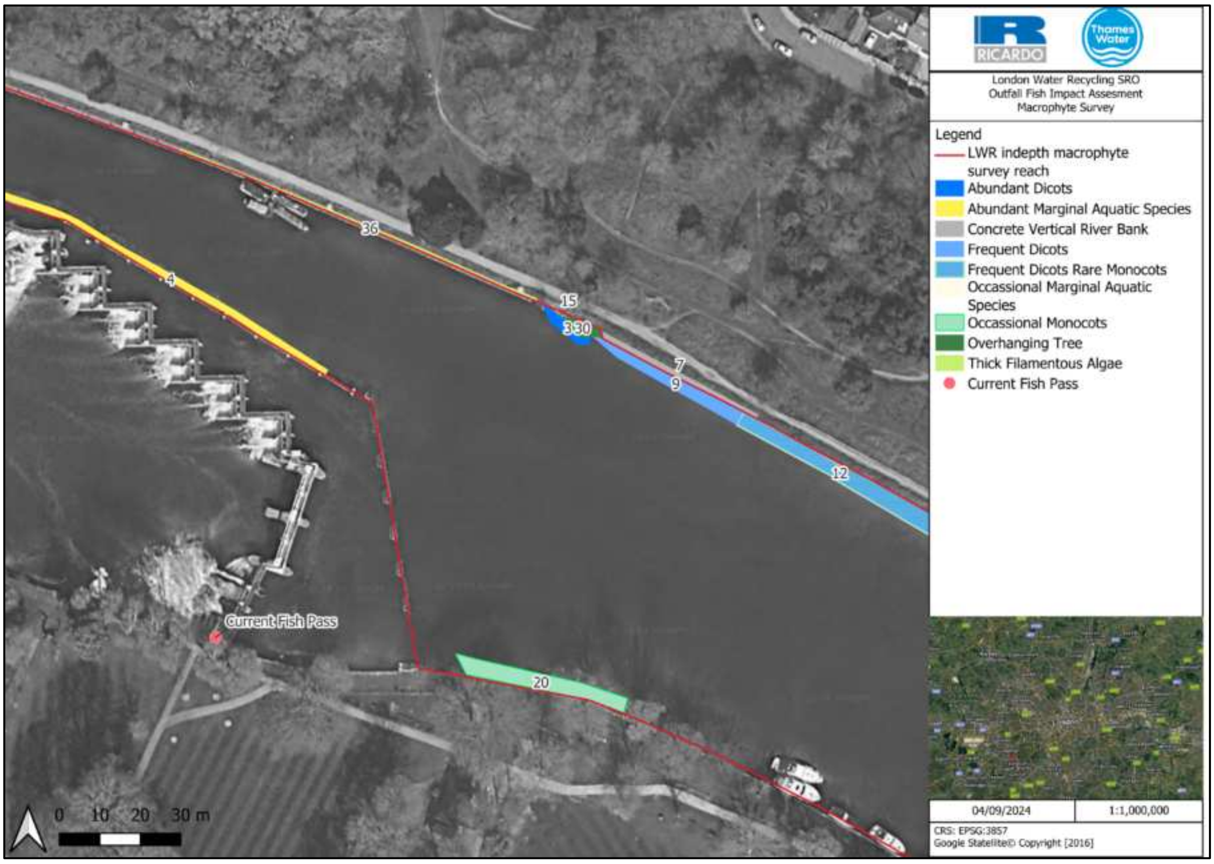


Plate A.48 Macrophyte mapping around the potential outfall location

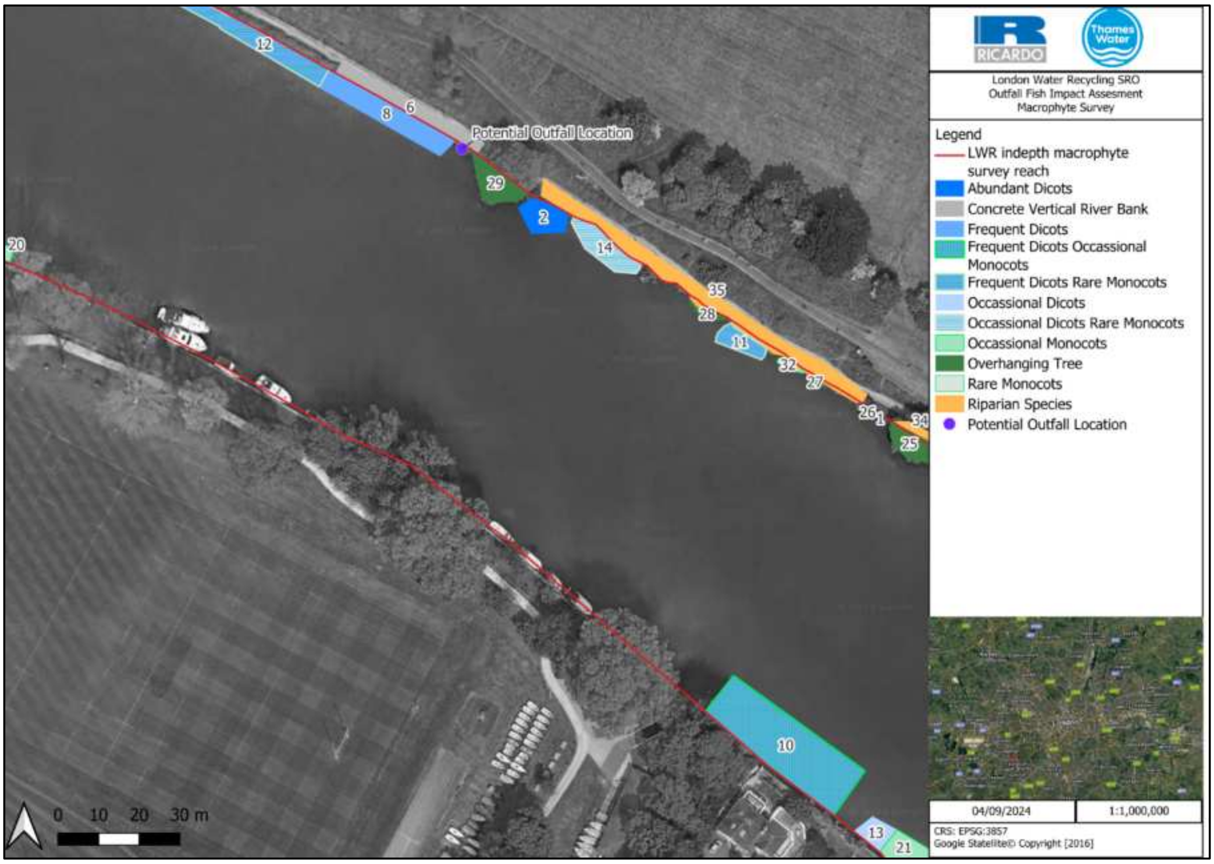


Plate A.49 Macrophyte mapping downstream of Trowlock Island

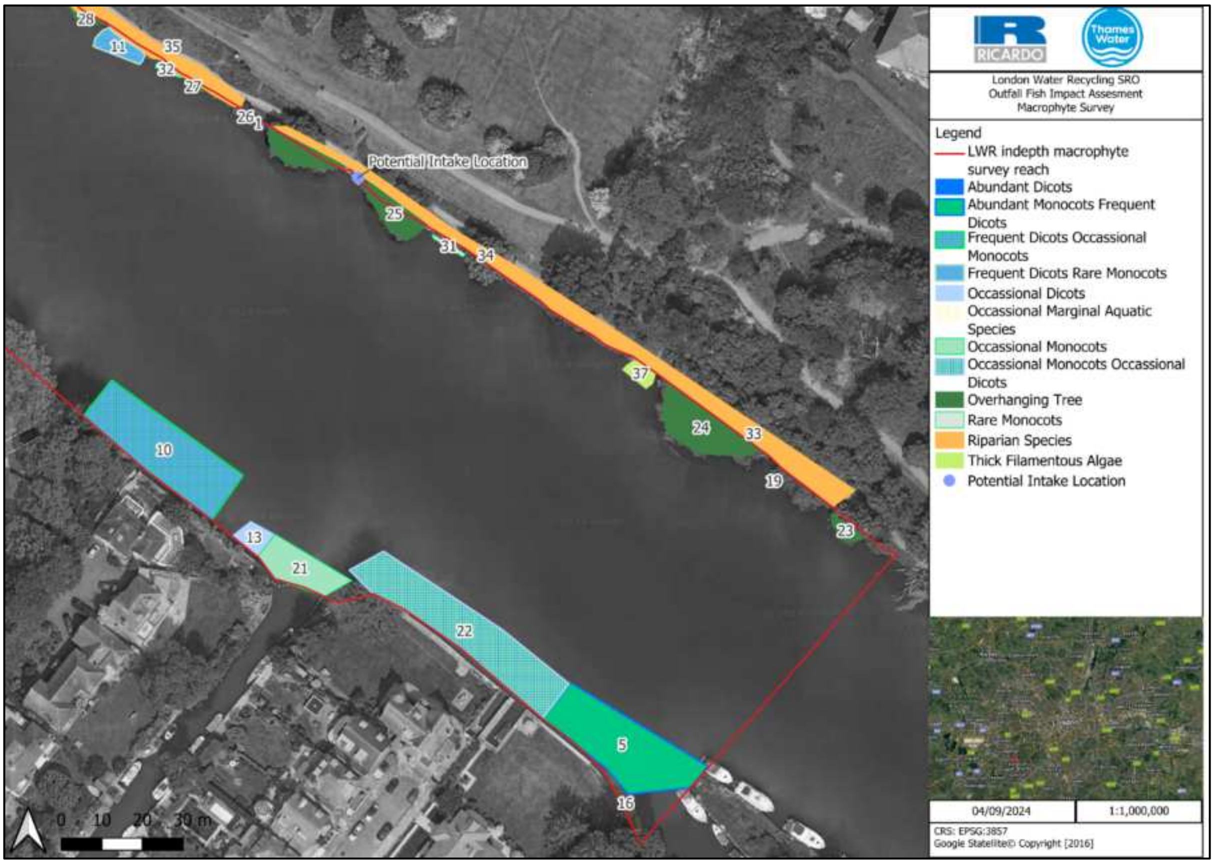


Table A.11 Descriptions of macrophyte taxa recorded during the survey in August 2024

Plate Number	Map Number	NGR	Description
Plate A.46	17	TQ 16784 71516	Small area (approximately 5m) of sparsely vegetated *Sparganium emersum* (unbranched bur-reed). The water here was deep and shaded by trees from the bank. Boat traffic in this area was high.
	18	TQ 16915 71472	Small area (approximately 6m) of sparsely vegetated *S. emersum.* This area was not shaded and was next to the barrier for Teddington Weir.
	4	TQ 16976 71444	Abundant growth of aquatic marginal species growing on top of the barrier for Teddington Weir (approximately 100m in length). Species included *Rumex hydrolapathum* (water dock), *Carex pendula* (pendulous sedge), *Scrophularia auriculata* (water figwort), *Mentha aquatica* (water mint), *Epilobium hirsutum* (great willowherb), *Iris pseudocorus* (yellow iris), *Scutellaria galericulata* (common skullcap), *Myosotis scorpioides* (water forget-me-not), *Eupatorium cannabinum* (hemp agrimony), *Lythrum*

Plate Number	Map Number	NGR	Description
			salicaria (purple loosestrife), *Sparganium erectum* (branched bur-reed), *Solanum dulcamara* (bittersweet) and *Lycopus europaeus* (gypsywort). There were small amounts of *Elodea nuttallii* (Nuttall's waterweed), an invasive non-native (INNS) and *Myriophyllum spicatum* (spiked water milfoil) growing under the barrier.
	36	TQ 17030 71454	A thick layer of *Cladophora glomerata/Rhizoclonium hieroglyphicum* (filamentous green algae) and *Octodiceras fontanum* (fountain pocket-moss) extensively covered the artificial right-hand bank.
	38	TQ 16788 71510	Wooded area on the left-hand bank, dominated by ornamental tree species. Some native species are in the understory, and some native marginal species, such as Solanum dulcamara and L. europaeus are present. *O. fontanum* was covering the artificial banks.
Plate A.47	3	TQ 17077 71429	An area (approximately 13m long) of abundantly vegetated *Nuphar lutea* (yellow waterlily) growing under and around an overhanging tree. A small patch of *M. spicatum* was also present upstream of the *N. lutea.*
	9	TQ 17106 71415	An area approximately 40m long, along the right-hand bank of sparsely/ frequently vegetated *M. spicatum*. *E. nuttallii* (an INNS) was occasional within the *M. spicatum.* Where it was present, the coverage was quite thick. *C. glomerata/R. hieroglyphicum* smothered a lot of the macrophytes in this area. The macrophytes spread approximately three meters into the channel from the bank.
	12	TQ 17145 71393	An area approximately 56m long, along the right-hand bank of sparsely/ frequently vegetated *M. spicatum,* with *E. nuttallii* and *S. emersum* rarely distributed throughout the area.
	20	TQ 17070 71342	An area (approximately 40m) of sparsely/ occasional *S. emersum* along the left-hand bank.
	15	TQ 17076 71433	A small area of occasional aquatic marginal species by the water's edge. Species include *M. aquatica, R. hydrolapathum, Filipendula ulmaria* (meadow sweet), *C. pendula* and *L. europaeus.*

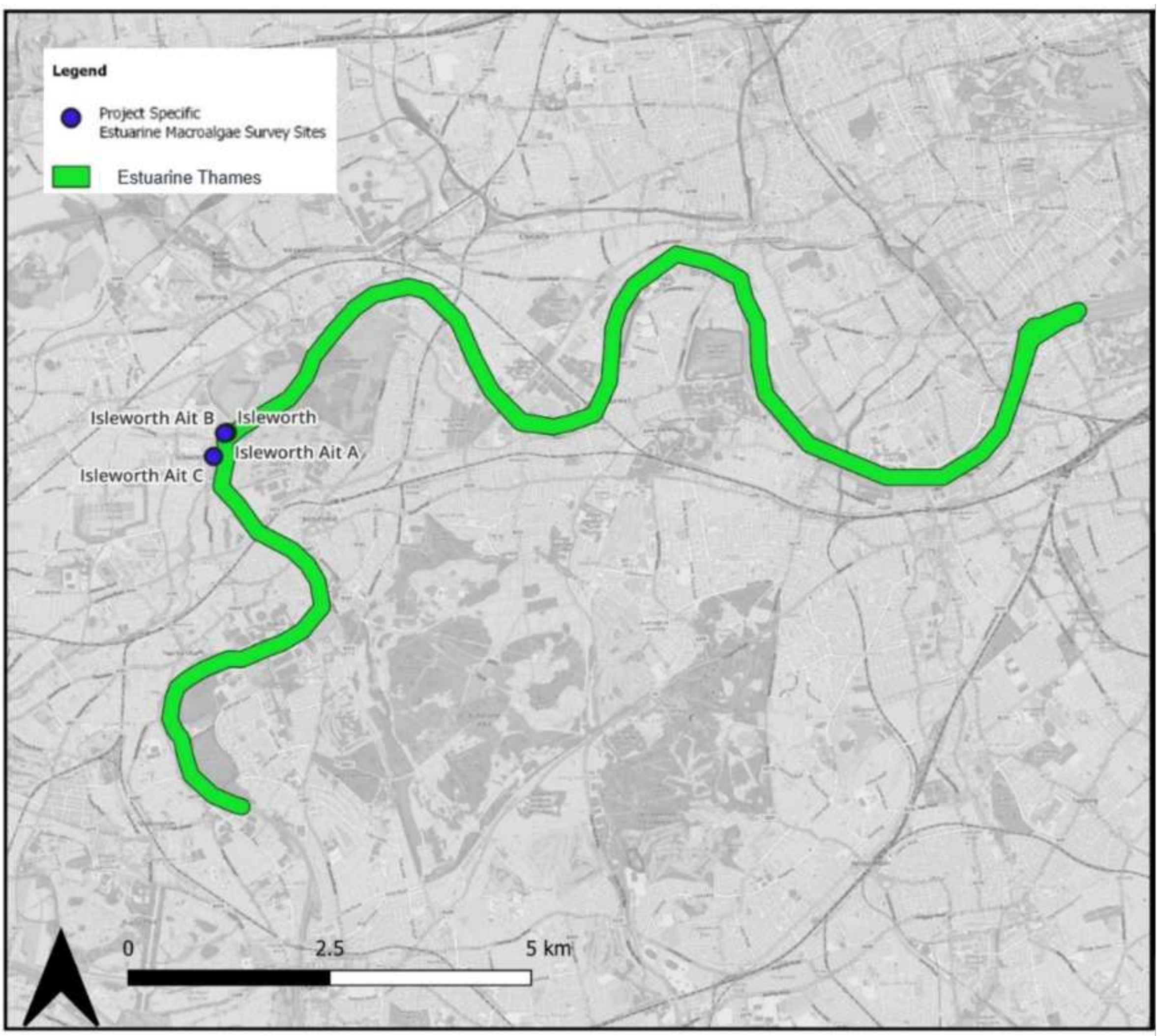
Plate Number	Map Number	NGR	Description
	30	TQ 17081 71430	Overhanging *Alnus glutinosa* (alder).
	7	TQ 17106 71417	Artificial concrete, vertical bank.
Plate A.48	8	TQ 17185 71371	An area approximately 35m long, along the right-hand bank of sparsely/ frequently vegetated *M. spicatum. E. nuttallii* (an INNS) was also occasionally found at the downstream end of the reach. *Fontinalis antipyretica* (greater water-moss) was growing occasionally in the margins on the bed substrate and *C. glomerata/R. hieroglyphicum* was also present.
	2	TQ 17223 71346	Small area (approximately 11m) of abundant *N. lutea* with rare *S. emersum.*
	14	TQ 17239 71338	An area (approximately 20m) of sparse/ occasional *E. nuttallii, S. emersum* and *N. lutea*. *C. pendula* was growing along the banks.
	11	TQ 17271 71315	A small area (approximately 12m in length) of sparsely/ frequently growing *E. nuttallii* and *Ceratophyllum demersum* (hornwort) with *S. emersum* growing rarely throughout.
	32	TQ 17283 71310	Small area of very sparsely growing *S. emersum.* Other species present were *E. nuttallii, C. demersum* and *F. antipyrectica*. All species were rare in the area.
	1	TQ 17306 71296	One very small (2m) area of densely growing *N. lutea.*
	10	TQ 17283 71215	A large area (approximately 40 x 12 meters) of a mixture of *S. emersum, Zannichellia palustris* (horned pondweed), *C. demersum* and *Sagittaria sagittifolia* (arrowhead) along the left-hand bank.
	13	TQ 17305 71194	A small area of sparsely vegetated/ occasional *Z. palustris* on the left-hand bank.
	29 28 27 26 25	TQ 17211 71354 TQ 17263 71322 TQ 17290 71305 TQ 17303 71298 TQ 17341 71273	Overhanging *A. glutinosa* and *Salix* sp. (willow) on the right-hand bank.

Plate Number	Map Number	NGR	Description
	6	TQ 17190 71373	Artificial concrete, vertical river bank.
	35 34	TQ 17263 71326 TQ 17365 71262	Riparian plant species along the bank, including *Acer pseudoplatanus* (sycamore trees), *Rubus fruticosus* (brambles), *E. canabinum, C. pendula, L. salicaria, Oenanthe crocata* (hemlock water-dropwort) *R. hydrolapathum, I. pseudacorus, and S. galericulata.*
Plate A.49	31	TQ 17353 71266	An approximate 9m area of very sparsely vegetated/ rarely occurring *S. emersum.*
	37	TQ 17400 71235	An area of thick *C. glomerata/R. hieroglyphicum* covering the substrate.
	19	TQ 17433 71208	A small area of sparsely vegetated *S. emersum.*
	21	TQ 17317 71186	An area around a side channel on the left-hand banks of sparsely vegetated *S. emersum*.
	22	TQ 17357 71171	A large area (approximately 56m) along the left-hand bank of occasional *S. emersum* growing in the deeper areas of the channel and *Z. palustris* growing in the shallower areas along the bank.
	5	TQ 17396 71144	A large area (approximately 39m) along the left-hand bank of a mixture of *S. emersum*, *C. glomerata/R. hieroglyphicum*, *E. nuttallii*, *Potamogeton* fressii (flat-stalked pondweed), *S. sagitifolia, M. spicatum*, C. demersum, *Nitella sp*. (stonewort), *Z. palustris*.
	16	TQ 17397 71129	Small area of occasional marginal aquatic species at the water margin on the left-hand bank. These were *L. salicaria* and *C. pendula.*
	24 23	TQ 17415 71222 TQ 17451 71196	Overhanging Salix sp on the right-hand bank.
	33	TQ 17428 71222	Riparian plant species growing along the right hand bank. A number of trees were present: *Salix sp., Fraxinus excelsior* (ash) and *A. pseudoplatanus.* Other species present along the bank included *R. fruticosus,* a large *Carex sp*. (sedge), *O. crocata, C. pendula*, *I. pseudacorus* and *L. europaeus*.

Estuarine River Thames (Teddington Weir to Battersea)

A.2.134 Macrophyte community data for the Thames Tideway is based on one site sampled by the Environment Agency in 2023 (Table A.9). Results from a macroalgae survey conducted by Jacobs along the side channel of Isleworth Ait in the vicinity of the Mogden STW outfall in 2023 are also outlined below[13]. Monitoring locations can be found in Plate A.50.

Plate A.50 Estuarine macroalgae monitoring locations



A.2.135 A total of eight taxa were recorded at Site 212973, all with a percentage cover less than 0.1%. Three of the species were algae: water felt (*Vaucheria* sp.), blue-green algal scum/pelt and gutweed (*Enteromorpha flexuosa*), which is an estuarine algae. Two in-channel species, unbranched bur-reed (Sparganium emersum) and least duckweed (*Lemna minuta*), were present.

A.2.136 RMNI scores were in line with the expected RMNI for the site, indicating that there was no nutrient enrichment at the site. NTAXA and NFG at the site were lower than expected, suggesting that the diversity and cover of plants at the site were low. Algal cover (ALG) was low at the site, which did not indicate any nutrient enrichment. The overall survey EQR from Site 212973 was indicative of

[13] Jacobs UK Limited (2023) Thames Water LWR SRO Gate 3 Macroalgae Monitoring 2023.

good ecological status (0.8) (App. Table 2 12.). EA Site 212973 is on the boundary between the freshwater and Thames Tideway and as such is unlikely to be very representative of the full Thames Tideway study area. The low number of species recorded at this site means that the overall survey result may not be fully accurate.

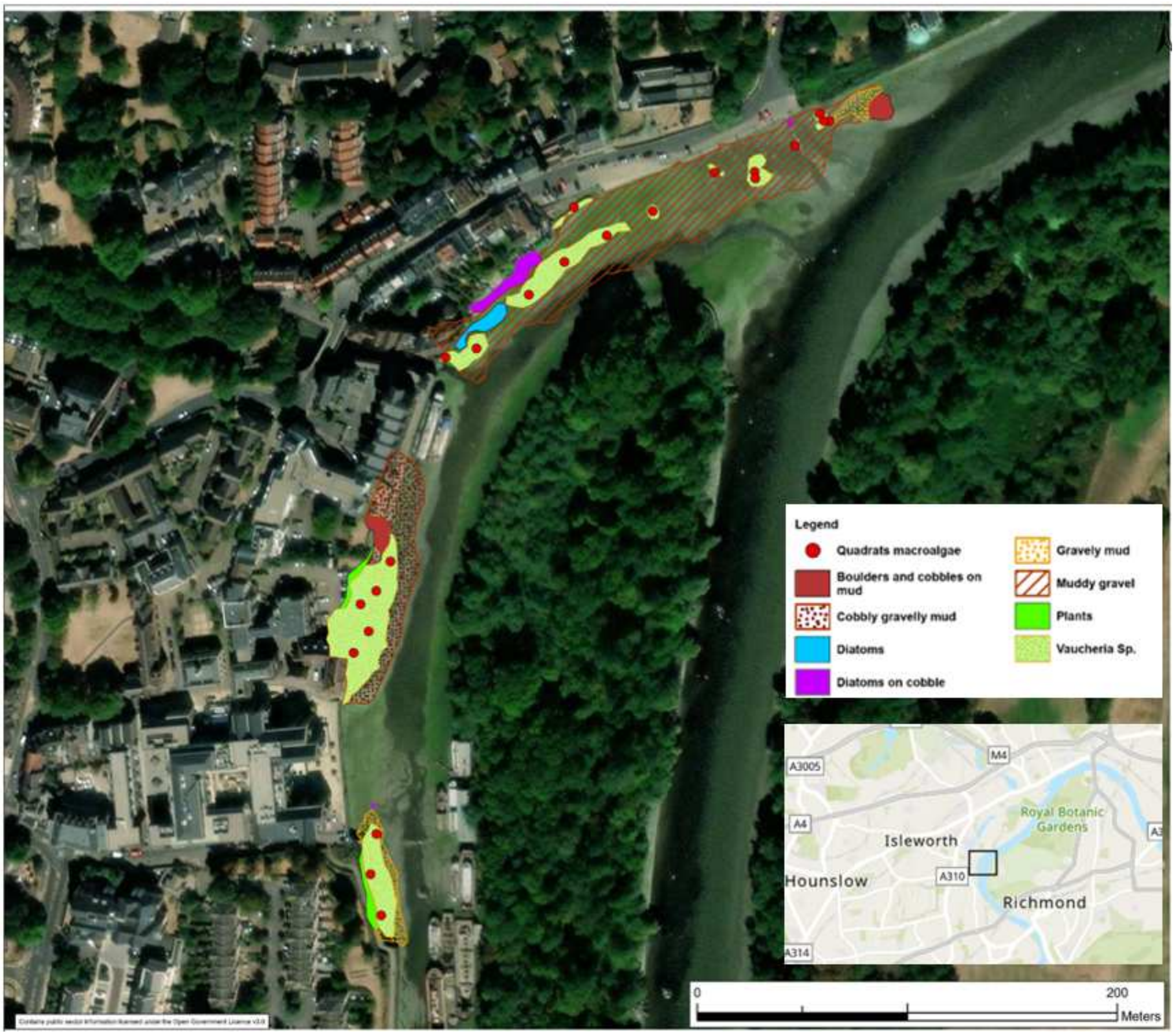
Table A.12 Macrophyte observed and expected indices summary for the Thames Tideway

Site ID	Site NGR	Survey count	Survey Range	RMHI score Min - Max (AVG.)	RMNI score Min - Max (AVG.)	RMNI EQR Min - Max (AVG.)	NTAXA Min - Max (AVG.)	NTAXA EQR Min - Max (AVG.)	NFG score Min - Max (AVG.)	NFG EQR Min - Max (AVG.)	ALG (% cover) Min - Max (AVG.)	ALG EQR Min - Max (AVG.)	Survey EQR score Min - Max (AVG.)	Survey EQR Class Min - Max (AVG.) B/P/M/G/H
c	TQ1681671534	1	2023	7.5	7.6	0.99	5	0.51	4	0.42	0.1	1	0.8	G

A.2.137 A total of 15 quadrats were recorded along the Isleworth Island survey area, and results are outlined in Plate A.51. The substrate around the survey areas consisted of gravely mud with overlying cobbles and boulders. The only recorded algae was water felt (*Vaucheria* sp.), which was patchily distributed across the intertidal zone. *Vaucheria* species are mostly found in freshwater or low-salinity estuarine waters, while a small number are fully marine.

A.2.138 Across the upper foreshore of Isleworth Ait, water starwort (*Callitriche* sp.) was found in occasional patches on sediment/gravel, along with scattered seedlings of purple loosestrife (*Lythrum salicaria*). The retaining wall/embankment was colonised by: purple loosestrife, gypsywort (*Lycopus europaeus*), hairy buttercup (*Ranunculus sardous*), peppermint (*Mentha × piperita*), bullrush (*Typha* sp.), buddleia, great yellow-cress (*Rorippa amphibia*), pale persicaria (*Persicaria lapathifolia*), broad-leaved dock (*Rumex obtusifolius*), water figwort (*Scrophularia umbrosa*), Mexican fleabane *Erigeron* (*karvinskianus* sp.), bramble (*Rubus fruticosus*), brooklime (*Veronica beccabunga*), common nettle (U*rtica dioica*) as well as Himalayan balsam (*Impatiens glandulifera*) (an INNS). This plant community indicates that the site may be predominantly freshwater-influenced.

Plate A.51 Macroalgae results from 2023



Macroinvertebrates

A.2.139 Table A.13 shows the full list of macroinvertebrates site locations used to establish the baseline for the freshwater and Thames Tideway.

Table A.13 The full list of phytoplankton site locations used to establish the baseline for the freshwater and Thames Tideway.

Study Area	Site Names	NGR
Freshwater Thames	LRUS 007	TQ1187369039
	LRUS 008	TQ1318169115
	LRUS 004	TQ1529868498
	LRUS 005/EA 35900	TQ1744067824
	LRUS 006/EA 188056	TQ1741471171
	LRUS 009	TQ1722171306

Study Area	Site Names	NGR
	LRUS 005	TQ1755068013 - TQ1743367811
Estuarine Thames	98142	TQ1678371477
	LRUS 011	TQ1640771795
	LRUS 012	TQ1711474993
	LRUS 013	TQ1842677610
	LRUS 014	TQ1935077695
	LRUS 015	TQ2172777782

Freshwater River Thames (Thames Water Walton Intake to Teddington Weir)

A.2.140 Macroinvertebrate community data is based on six sites located between the Thames Water Walton intake and Teddington Weir (Table A.14). These six sites were sampled by Ricardo in spring and autumn from autumn 2021 to autumn 2023 (including summer 2023). Two of the sites were EA sites, which were sampled intermittently by the EA between 2006 and 2023 (14 samples in total). Monitoring locations can be found in Plate A.52.

A.2.141 The majority of the macroinvertebrate community was made up of the following taxonomic groups: molluscs (*Mollusca)*, worms (*Annelids),* crustaceans (*Crustacean*), caddisflies (*Trichoptera*), mayflies (*Ephemeroptera*) and true flies (*Diptera*). Molluscs were the taxon group with the highest abundance and diversity of taxon. Taxon of the following families were present: pea clam (*Sphaeriidae*), ram's horn snail (*Planorbidae*), pond snails (*Lymnaeidae*) and river snails (*Viviparidae*). Taxon which may be sensitive to environmental changes were also present: crawling water beetles (*Haliplidae*), riffle beetles (*Elmidae*), long-horned caddisfly (*Leptoceridae*), small square-gilled mayfly (*Caenidae*) and burrowing mayfly (*Ephemeridae*).

Plate A.52 Freshwater macroinvertebrate monitoring locations

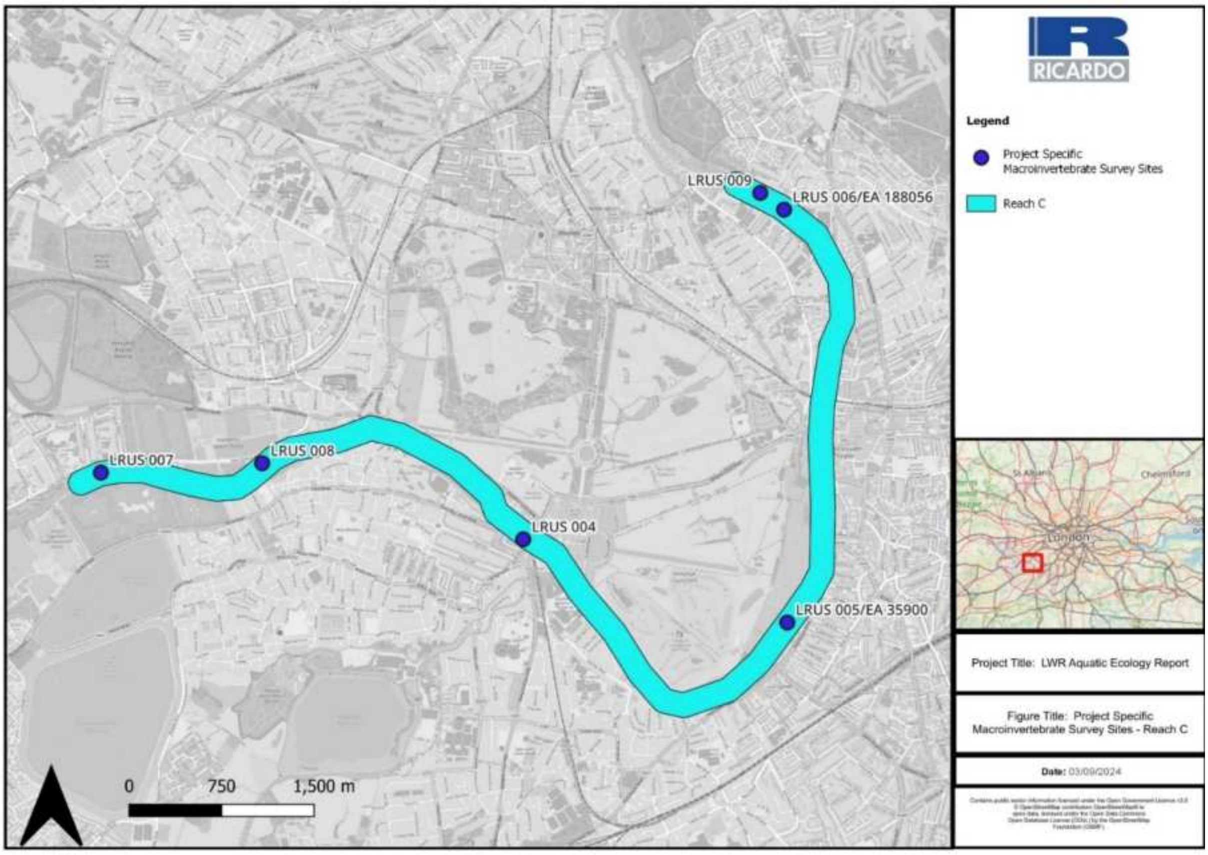


Table A.14 Macroinvertebrate observed and expected indices summary

Site ID	Site NGR	Survey count	Survey Range	LIFE EQR score Min - Max (AVG.)	LIFE (Family) EQR Class Min - Max (AVG.) *B/P/M/G/H*	LIFE (Family) SCORE Min - Max (AVERAG.)	WHPT ASPT EQR score Min - Max (AVG.)	WHPT ASPT EQR Class Min - Max (AVG.) *B/P/M/G/H*	WHPT ASPT Score Min - Max (AVG.)	WHPT NTAXA EQR score Min - Max (AVG.)	WHPT NTAXA EQR Class Min - Max (AVG.) *B/P/M/G/H*	WHPT NTAXA SCORE Min - Max (AVERAG.)	PSI (Family) EQR score Min - Max (AVG.)	PSI (Family) EQR Class Min - Max (AVG.) *B/P/M/G/H*	PSI (Family) SCORE Min - Max (AVERAG.)
LRUS 007	TQ1187369039	3	2021 to 2022	0.87 - 1.01 (0.94)	M - H (H)	6.38 - 7.5 (6.93)	0.64 - 0.81 (0.72)	P - M (M)	4.18 - 5.56 (4.89)	0.54 - 0.71 (0.62)	P - G (M)	10 - 14 (12)	0.07 - 0.65 (0.31)	M - M (M)	5 - 45 (21.11)
LRUS 008	TQ1318169115	3	2021 to 2022	0.88 - 0.9 (0.89)	M - M (M)	6.5 - 6.68 (6.58)	0.6 - 0.64 (0.61)	P - P (P)	3.9 - 4.39 (4.13)	0.41 - 1.12 (0.73)	B - H (G)	8 - 22 (14)	0.08 - 0.26 (0.18)	M - M (M)	5.26 - 17.65 (12.69)
LRUS 004	TQ1529868498	3	2021 to 2022	0.86 - 0.96 (0.91)	M - H (M)	6.33 - 7.13 (6.71)	0.65 - 0.71 (0.68)	P - P (P)	4.44 - 4.89 (4.6)	0.38 - 0.92 (0.64)	B - H (M)	7 - 18 (12)	0.11 - 0.45 (0.34)	M - M (M)	7.69 - 31.25 (22.98)
LRUS 005/EA 35900	TQ1744067824	16	2006 to 2023	0.85 - 0.96 (0.92)	M - H (M)	6.12 - 6.79 (6.52)	0.67 - 0.91 (0.84)	P - G (M)	3.8 - 5.16 (4.66)	0.21 - 1 (0.67)	B - H (M)	6 - 29 (20)	0.08 - 0.52 (0.32)	M - M (M)	3.85 - 27.5 (16.16)
LRUS 006/EA 188056	TQ1741471171	10	2017 to 2023	0.8 - 0.93 (0.86)	M - M (M)	5.84 - 6.9 (6.3)	0.55 - 0.76 (0.65)	B - M (P)	3.57 - 5.2 (4.31)	0.16 - 1.4 (0.78)	B - H (G)	3 - 26 (15)	0.12 - 0.34 (0.2)	M - M (M)	7.84 - 23.53 (13.98)
LRUS 009	TQ1722171306	6	2021 to 2023	0.85 - 0.96 (0.9)	M - H (M)	6.25 - 7 (6.62)	0.49 - 0.66 (0.6)	B - P (P)	3.22 - 4.54 (3.93)	0.27 - 0.77 (0.52)	B - G (P)	5 - 15 (10)	0.07 - 0.26 (0.15)	M - M (M)	4.55 - 18.18 (10.1)

A.2.142 Walley Hawkes Paisley Trigg (WHPT) average score per taxon (ASPT) from all the available results was indicative of a macroinvertebrate community with a high tolerance to nutrients. WHPT ASPT ranged from 3.22 – 5.56 (Plate A.53). WHPT ASPT ecological quality ratio (EQR) scores for most of the sites were indicative of poor to moderate status (see Table A.15). Except for LRUS 005/EA 35900, which had ASPT indicative of moderate to good ecological status for the majority of surveys, LRUS 006/EA 188056 and LRUS 009 which had ASPT indicative of bad ecological status on a number of occasions. ASPT EQR scores generally suggest that nutrient levels at these sites are higher than would be expected for the River Thames.

A.2.143 WHPT number of scoring taxa (NTAXA) ranged from 3 – 29 (Plate A.54). NTAXA throughout the sampling period was very variable, with indicative EQRs ranging from bad to high ecological status. The majority of NTAXA scores from 2021 onwards were indicative of poor to moderate ecological status.

Table A.15 WFD macroinvertebrate EQR classification boundaries

WHPT Classification	WHPT ASPT EQR	WHPT NTAX EQR
High	>0.97	>0.8
Good	0.86 - 0.97	0.68 - 0.8
Moderate	0.72 - 0.86	0.56 - 0.68
Poor	0.59 - 0.72	0.47 - 0.56
Bad	<0.59	<0.47

Plate A.53 Macroinvertebrate WHPT ASPT EQR indices and raw scores

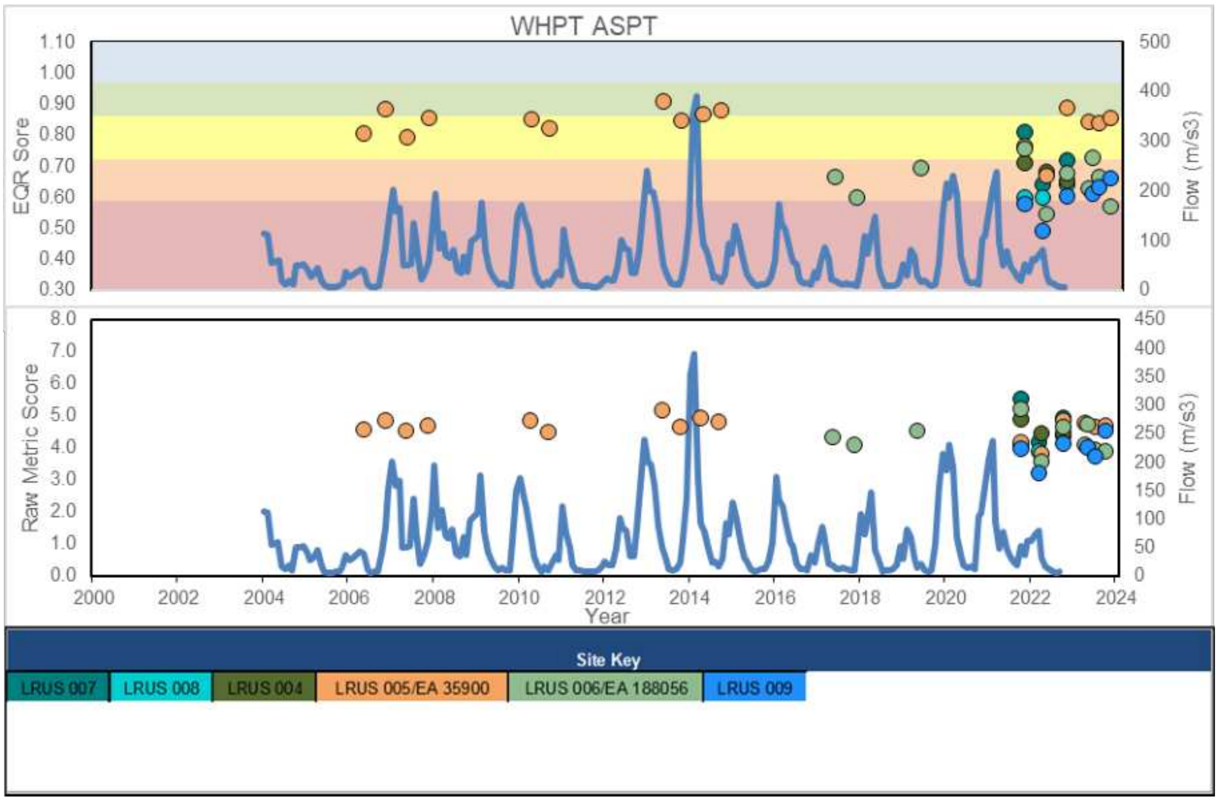
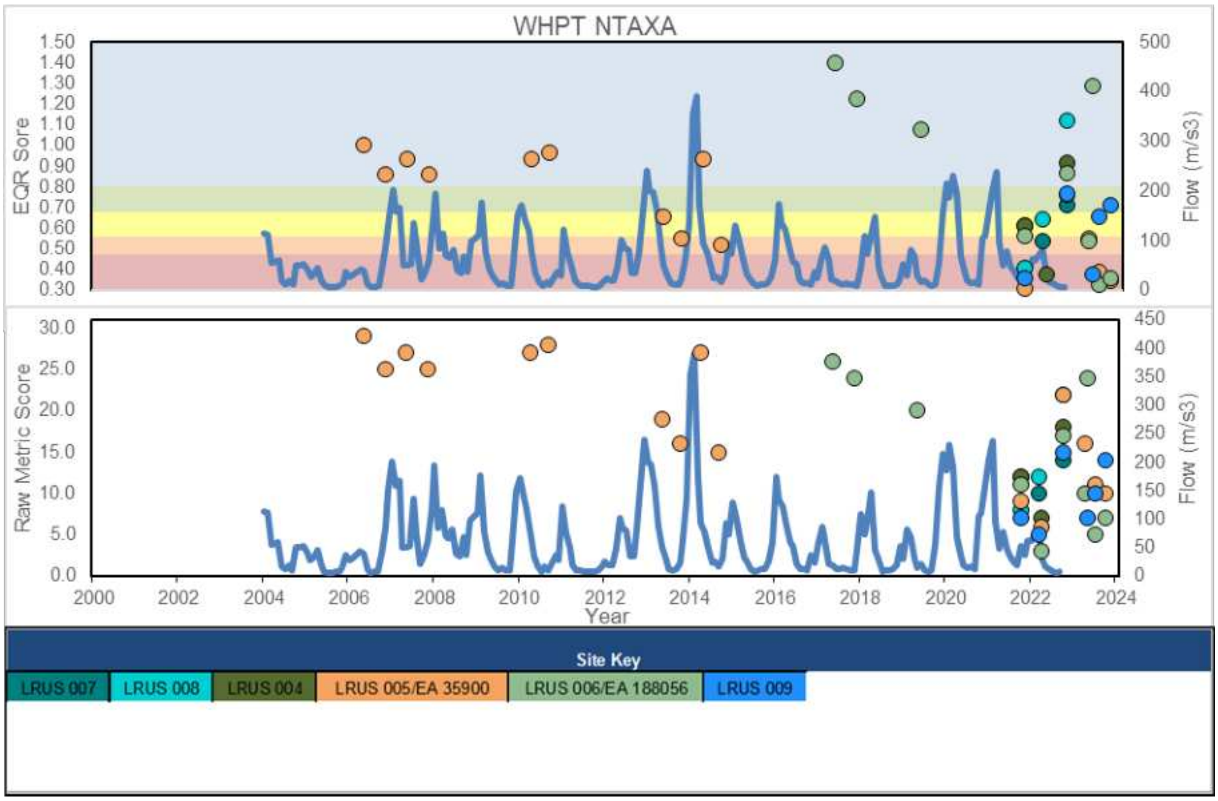


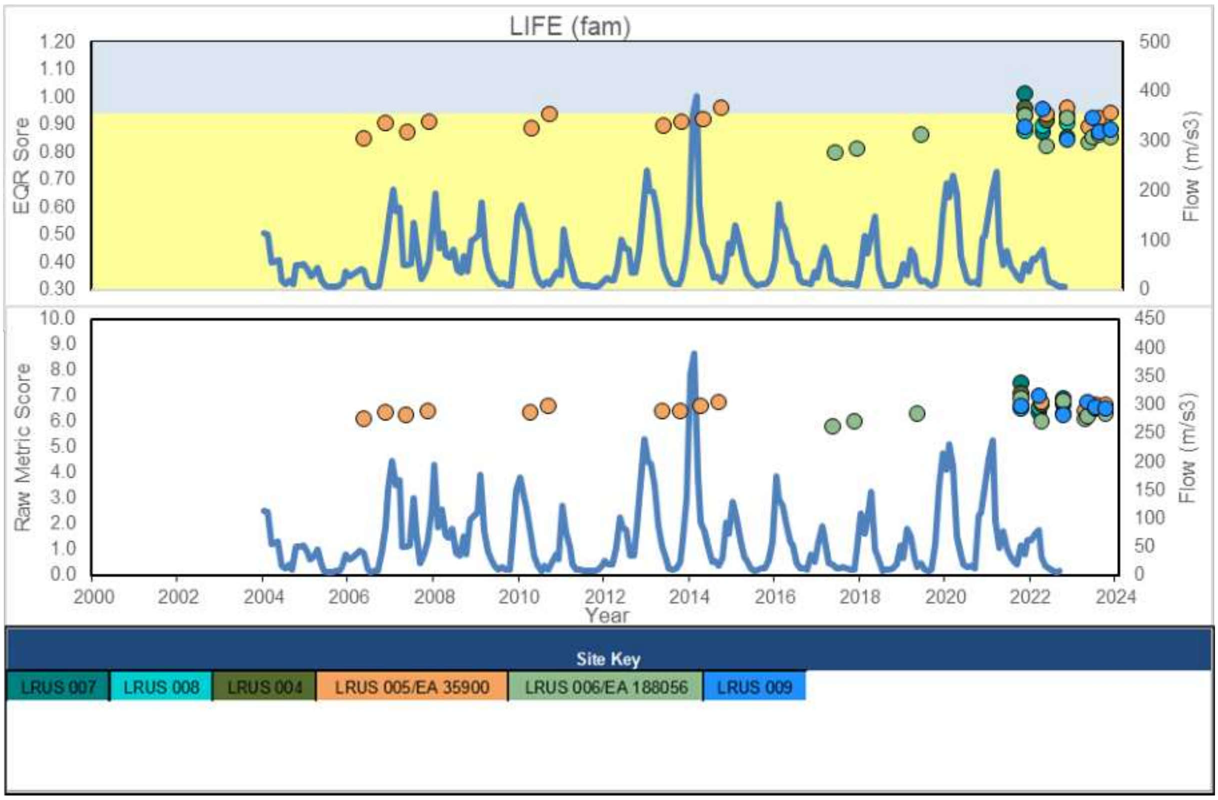
Plate A.54 Macroinvertebrate WHPT NTAXA EQR indices and raw scores



A.2.144 Lotic-invertebrate Index for Flow Evaluation (LIFE)(family) indices are not used to determine WFD classifications but indicate flow preferences within a macroinvertebrate community. LIFE scores from the recorded taxa were indicative of a macroinvertebrate community tolerant of slow to moderate flowing conditions[14]. A LIFE EQR below 0.94 is indicative of a macroinvertebrate community that may be experiencing stress due to low flows. The majority of LIFE EQR scores were below 0.94, indicating that the macroinvertebrate community may be impacted by low flows along the freshwater Thames within the study area (Plate A.55).

A.2.145 Proportion of Sediment-sensitive Invertebrates (PSI) indices are also not used to determine WFD classification but can be used as an indication of the level of sedimentation and eutrophication at the sites. PSI from the sites suggests the macroinvertebrate community is associated with moderately to heavily sedimented riverbed conditions. The taxa recorded are generally not sensitive to sedimentation, with a small number of species present that are sensitive to sedimentation[15]. A PSI EQR value below 0.70 is indicative of an invertebrate community experiencing possible stress associated with fine sediment input. PSI EQR scores for all samples were below 0.70, indicating that the macroinvertebrate community recorded may be impacted due to sedimentation (Plate A.56).

Plate A.55 Macroinvertebrate LIFE(family) EQR indices and raw scores



[14] Extence C.A., Balbi D.M. and Chadd R.P. (1999) River Flow Indexing using British Benthic Macroinvertebrates: A Framework for Setting Hydroecological Objectives. Regulated Rivers: Research and Management 15, 543-574.
[15] Extence C.A., Chadd R.P., England J., Dunbar M.J., Wood P.J. and Taylor E.D. (2011) The Assessment of Fine Sediment Accumulation in Rivers using Macroinvertebrate Community Response. River Research and Applications. Wiley Online Library DOI: 10.1002/rra.1569

Plate A.56 Macroinvertebrate PSI(family) EQR indices and raw scores

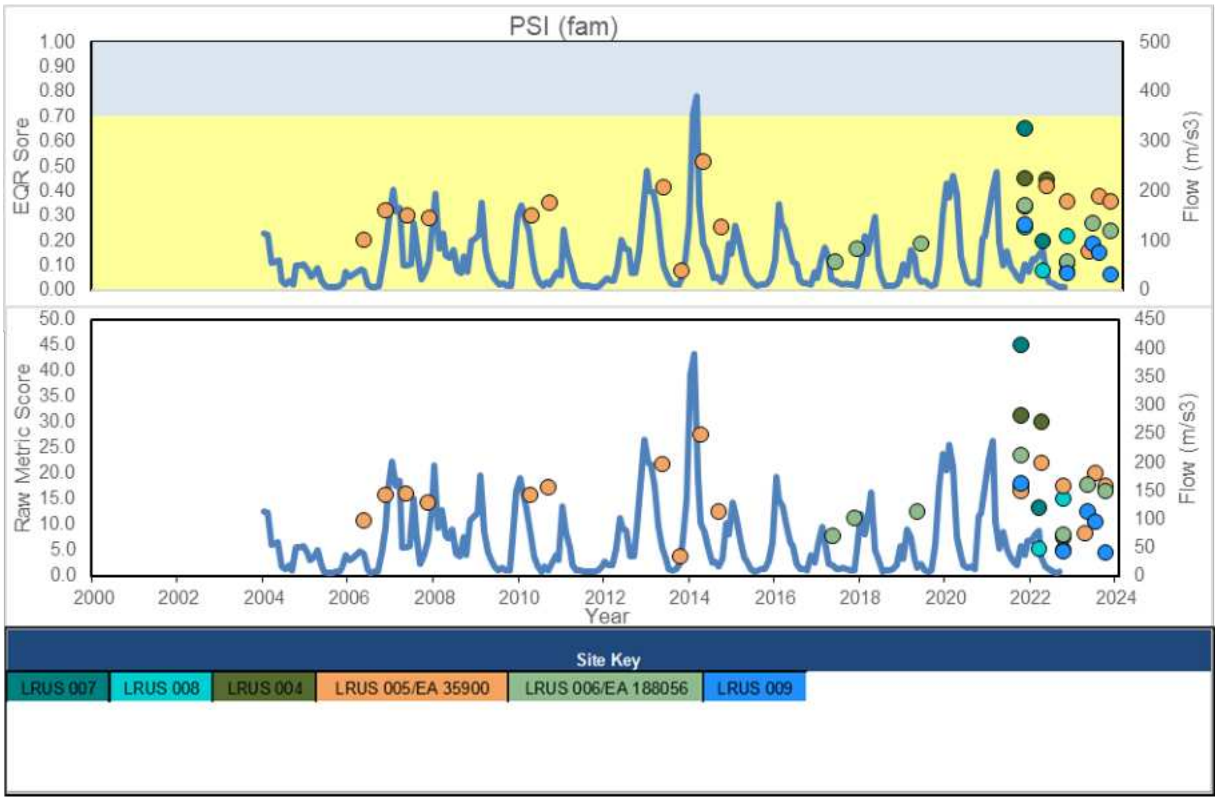
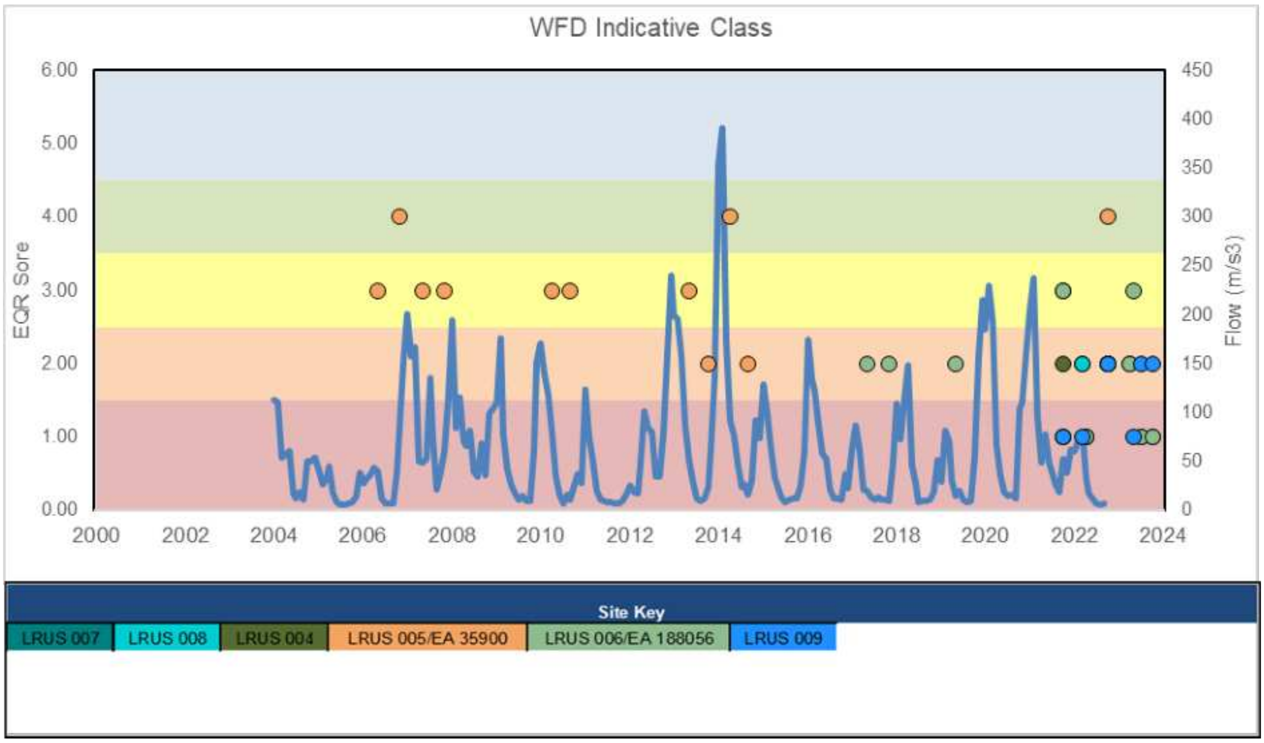


Plate A.57 Macroinvertebrate WFD indicative classifications for all surveys



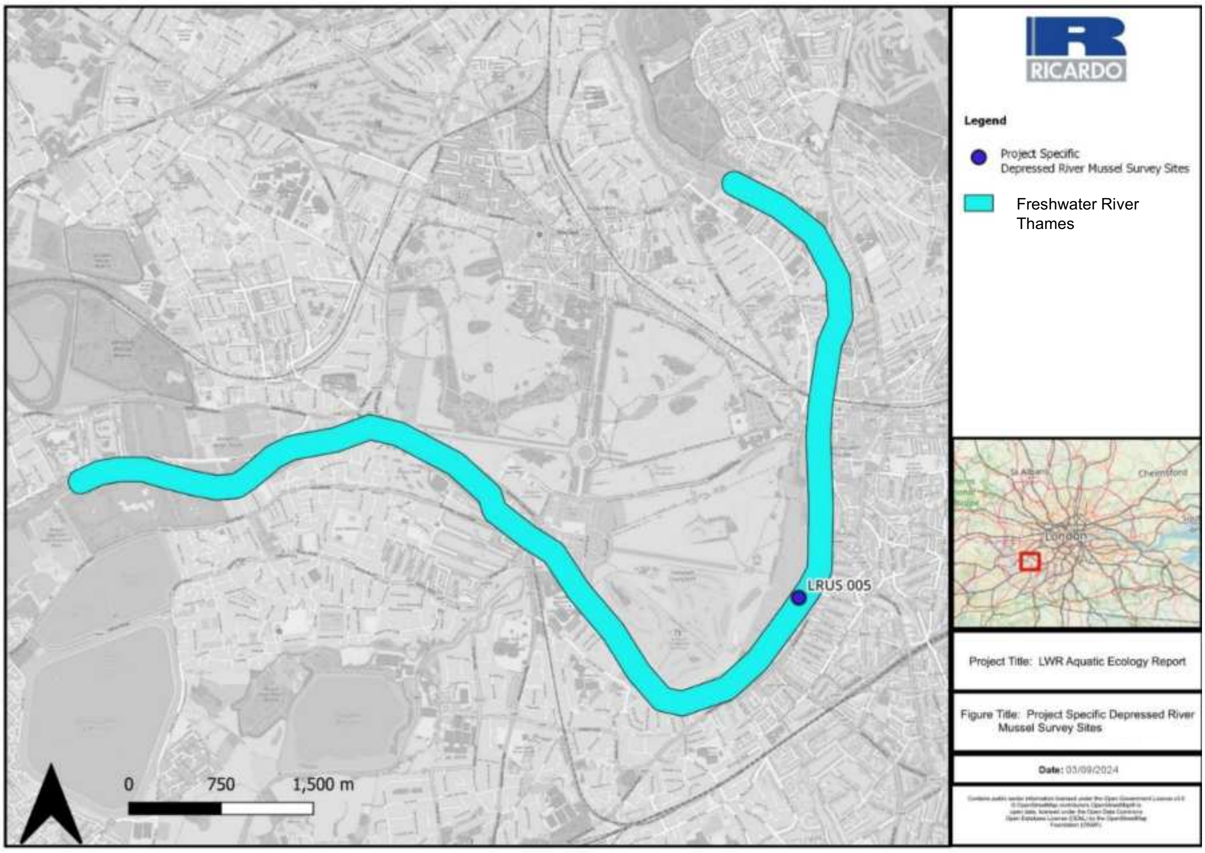
A.2.146 Eight designated species were identified through the surveys conducted, and these are listed in the Protected and Notable Species section. The protected species recorded are swollen river mussel (*Unio tumidus*), river orb mussel (*Sphaerium rivicola*), riffle beetle (*Stenelmis canaliculata*), depressed river mussel (*Pseudanodonta complanate*), striped mayfly (*Ephemera lineata*), riffle beetle (*Macronychus quadrituberculatus*), Lister's river snail (*Viviparus contectus*) and dark-winged soldier fly (*Oxycera analis*).

A.2.147 Invasive non-native macroinvertebrate species (INNS) identified during the surveys are listed in Table A.42. The INNS recorded are tubificid worm (*Branchiura sowerbyi*), Caspian mud shrimp (*Chelicorophium curvispinum*), Asian clam (*Corbicula fluminea*), norther river shrimp (*Crangonyx pseudogracilis*), Florida Crangonyx (*Crangonyx pseudogracilis/ floridanus*), demon shrimp (*Dikerogammarus haemobaphes*), quagga mussel (*Dreissena bugensis*), zebra mussel (*Dreissena polymorpha*), American immigrant triclad (*Dugesia tigrine* and *Girardia tigrina*), Wautier's limpet (*Ferrissia californica*), Ponto-Caspian polycheate worm (*Hypania invalida*), trumpet ramshorn (*Menetus dilatatus*), long fingernail clam (*Musculium transversum*), bladder snail (*Physella acuta*) and New Zealand mudsnail (*Potamopyrgus antipodarum*).

Depressed River Mussels (DRM) – Freshwater Thames

A.2.148 Depressed River Mussel (*Pseudanodonta complanata)* surveys were conducted at one site within the freshwater Thames between Hampton and Teddington Weir in 2021 and 2023. This site was located downstream of Surbiton Intake at Raven's Ait Island in Kingston. The monitoring location of the survey can be found in Plate A.58.

Plate A.58 DRM monitoring location



A.2.149 No DRM were recorded during any of the surveys. Over 8500 individual bivalves were recorded across six species, with Asian Clam (*Corbicula fluminea*) making up the majority of these individuals. Counts for each species can be seen in Table A.16 below.

Table A.16 Results of DRM surveys within the freshwater River Thames between Hampton and Teddington Weir

Species	Site
	LRUS - 005
Anodonta anatina	5
Corbicula fluminea	7929
Dreissena polymorpha	84
Dreissena rostriformis bugensis	142
Unio pictorum	95
Unio tumidus	337
Grand Total	**8592**

A.2.150 Wider data searches for the macroinvertebrate section of this report found one record for one individual DRM at LRUS005/ EA 35900 in 2010. No further incidental records were recorded of DRM at this site during any invertebrate sampling since this record was in 2010.

A.2.151 Additional surveys were conducted at three sites upstream of Hampton between 2021 and 2023. No DRM were recorded during any of the surveys. One thousand six hundred ninety-four individual bivalves were recorded across nine species, with Asian Clam (*Corbicula fluminea*) making up the majority of these individuals. Counts for each species can be seen in Table A.17 below.

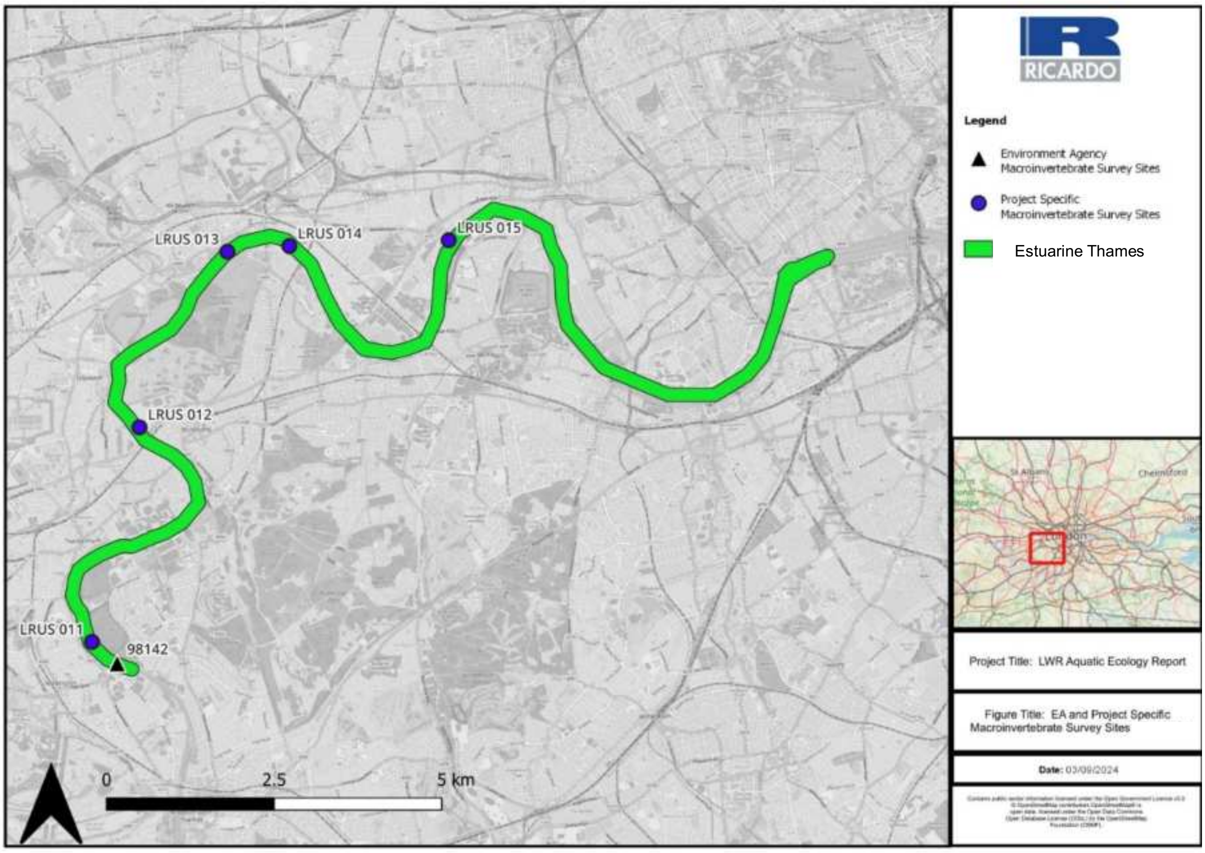
Table A.17 Results of DRM surveys within the freshwater River Thames upstream of Hampton

Species	LRUS - 021	Penton Hook Weir	U/s R. Ash	Grand Total
Anodonta anatina	5	17	35	57
Corbicula fluminea	455	18	429	902
Dreissena polymorpha	25	75	49	149
Dreissena rostriformis bugensis	1	16	2	19
Pisidium sp.		2		2
Sphaerium sp.	10	24	40	74
Unio pictorum	19	38	44	101
Unio sp.			1	1
Unio tumidus	133	61	195	389
Grand Total	**648**	**251**	**795**	**1694**

Estuarine River Thames (Teddington Weir to Battersea)

A.2.152 The macroinvertebrate community is based on six sites located between Teddington Weir and Battersea. Ricardo monitored five of these sites in the spring, summer, and autumn of 2021 to 2023. The EA monitored an additional site between 2005 and 2023 (104 samples in total). Monitoring locations can be found in Plate A.59.

Plate A.59 Estuarine macroinvertebrate monitoring locations



A.2.153 The majority of the macroinvertebrate community was made up of the following taxonomic groups: molluscs (Mollusca), crustaceans (Crustacean), worms (Annelids), mayflies (Ephemeroptera), true flies (Diptera), and caddisflies (Trichoptera). Molluscs were the most abundant group.

A.2.154 Walley Hawkes Paisley Trigg (WHPT) average score per taxon (ASPT) from all the available results was indicative of a macroinvertebrate community with a high tolerance to nutrients. WHPT ASPT ranged from 2.2 – 5.19 (Table A.18). WHPT ASPT ecological quality ratio (EQR) scores for most of the sites were indicative of bad status, with four of the six sites having EQR scores ranging from bad to poor across all surveys. LRUS 011 had an EQR indicative of poor, with moderate scores on occasion. Site 98142 had an EQR score indicative of good ecological status that ranged from poor to high across the 104 surveys. ASPT EQR scores generally suggest that nutrient levels at these sites are higher than would be expected for the River Thames.

A.2.155 WHPT number of scoring taxa (NTAXA) ranged from 2 – 28 (Plate A.54). NTAXA, throughout the sampling, was variable with indicative EQRs ranging from bad to high ecological status. 98142 is the only site to have received an indicative score of high ecological status. All project-specific samples from 2021 to 2023 scores indicated that ecological status was between bad and moderate.

A.2.156 LIFE(family) indices are not used to determine WFD classifications but indicate flow preferences within a macroinvertebrate community. LIFE scores from the recorded taxa were indicative of a macroinvertebrate community tolerant of slow to moderate conditions, with occasional samples being indicative of faster-flowing conditions. LIFE(family) scores ranged between 5 - 7.75, with the lowest LIFE(family) score of 5 at Site LRUS 012 in Autumn 2022 and the highest score of 7.75 at Site LRUS 011 in Autumn 2021. Four of the six sites had average LIFE EQR scores lower than 0.94, indicating that low flows along the Thames may impact the macroinvertebrate community.

A.2.157 PSI indices are not used to determine WFD classification but provide an indication of the level of sedimentation and eutrophication at the sites. PSI family scores from the sites suggest the macroinvertebrate community across the sites is associated with heavily sedimented to moderately sedimented riverbed conditions. Four of the six sites had PSI (Family) EQR scores of less than 0.7, suggesting that the macroinvertebrate community may be impacted due to sedimentation.

A.2.158 It must be noted that the above assessments are usually applied to freshwater rivers only and are not used to assess invertebrate communities in estuarine or saline environments. This section of the tidal River Thames is considered to have a high freshwater influence but is tidal, so the assessments were still applied as the communities are generally still comprised of freshwater invertebrate species. The results of the surveys did show a presence of species with a preference for saline conditions, such as the shrimp *Gammarus zaddachi,* although freshwater species still dominated the data.

Table A.18 Macroinvertebrate observed and expected indices summary (N.B. This table presents the results of the application of a freshwater classification methodology to the tidal River Thames (a transitional water body), and caution is required when interpreting the results.)

Site ID	Site NGR	Survey count	Survey Range	LIFE EQR score Min - Max (AVG.)	LIFE (Famliy) EQR Class Min - Max (AVG.) *B/P/M/G/H*	LIFE (Family) SCORE Min - Max (AVERAG.)	WHPT ASPT EQR score Min - Max (AVG.)	WHPT ASPT EQR Class Min - Max (AVG.) *B/P/M/G/H*	WHPT ASPT Score Min - Max (AVG.)	WHPT NTAXA EQR score Min - Max (AVG.)	WHPT NTAXA EQR Class Min - Max (AVG.) *B/P/M/G/H*	WHPT NTAXA SCORE Min - Max (AVERAG.)	PSI (Family) EQR score Min - Max (AVG.)	PSI (Family) EQR Class Min - Max (AVG.) *B/P/M/G/H*	PSI (Family) SCORE Min - Max (AVERAG.)
98142	TQ1678371477	106	2005 to 2024	0.86 - 1.15 (1.05)	M - H (H)	5.71 - 6.95 (6.44)	0.63 - 1.15 (0.97)	P - H (H)	3.61 - 5.19 (4.41)	0.17 - 0.96 (0.59)	B - H (M)	5 - 28 (16)	0.11 - 2.9 (1.15)	M - H (H)	4.76 - 40 (18.57)
LRUS 011	TQ1640771795	9	2021 to 2024	0.84 - 1.08 (0.98)	M - H (H)	6 - 7.75 (7.02)	0.65 - 0.98 (0.77)	P - H (M)	3.94 - 5.47 (4.67)	0.19 - 0.56 (0.34)	B - P (B)	4 - 12 (7)	0.25 - 0.93 (0.47)	M - H (M)	15 - 55.56 (27.83)
LRUS 012	TQ1711474993	9	2021 to 2024	0.68 - 0.98 (0.84)	M - H (M)	5 - 7.25 (6.23)	0.32 - 0.84 (0.6)	B - M (P)	2.2 - 4.93 (3.88)	0.15 - 1.05 (0.49)	B - H (P)	3 - 16 (9)	0.06 - 0.39 (0.19)	M - M (M)	4.35 - 27.27 (13.11)
LRUS 013	TQ1842677610	9	2021 to 2024	0.81 - 0.91 (0.86)	M - M (M)	6 - 6.83 (6.39)	0.52 - 0.68 (0.58)	B - P (B)	3.38 - 4.17 (3.79)	0.31 - 0.65 (0.46)	B - M (B)	6 - 12 (8)	0.12 - 0.29 (0.18)	M - M (M)	8.33 - 20 (12.62)
LRUS 014	TQ1935077695	9	2021 to 2024	0.82 - 0.96 (0.88)	M - H (M)	6 - 7 (6.53)	0.48 - 0.65 (0.56)	B - P (B)	2.85 - 4.3 (3.67)	0.1 - 0.53 (0.25)	B - P (B)	2 - 8 (4)	0.09 - 1.45 (0.62)	M - H (M)	5.88 - 100 (42.1)
LRUS 015	TQ2172777782	9	2021 to 2024	0.77 - 0.93 (0.83)	M - M (M)	5.8 - 6.89 (6.16)	0.44 - 0.62 (0.56)	B - P (B)	3 - 4.22 (3.67)	0.32 - 0.51 (0.42)	B - P (B)	6 - 10 (8)	0.12 - 0.32 (0.18)	M - M (M)	8 - 22.22 (12.1)

Fish

A.2.159 Details on the baseline fisheries population specific to the Project can be found in the Fisheries Consolidated Report[16].

Freshwater River Thames (Thames Water Walton Intake to Teddington Weir)

A.2.160 A total of 40 fisheries surveys across eight unique sites (Plate A.60), institute the baseline dataset for the freshwater River Thames from Thames Water Walton Intake to Teddington Weir, with Environment Agency (EA) monitoring representing a large portion of the available baseline dataset. Additionally, several project-specific monitoring surveys were completed from 2021 to 2023 following recommendations made within the Gate 1 assessment report. Further details may be found in Annex B2.3: Fish Assessment Report, Standard Gate Two submission for LWR SRO[17].

Table A.19 shows the full list of fish site locations used to establish the baseline for the freshwater and tidal River Thames

Study Area	Site Names	NGR
Freshwater River Thames	D/S Walton Intake	TQ1187468995
	Between TW Walton and Hampton intake	TQ1255768953
	Molesey Weir	TQ1492768955
	Molesey – Thames Ditton Island, Upper Main Channel	TQ1526868507
	Between Sunbury Lock and Surbiton intake	TQ1601867759
	LTOA Ham Road	TQ1786070710
	TDRA Intake/Outfall	TQ1723671345
	LRUS-005	TQ1744067824

A.2.161 The full dataset for the freshwater River Thames includes:

a. Existing freshwater ecological datasets:

i. National Fish Population Database (NFPD): Freshwater fish counts for all species for all areas and all years (2010 – 2023). NFPD consists of information collected from fisheries monitoring work on rivers and lakes. The EA undertakes this monitoring work.

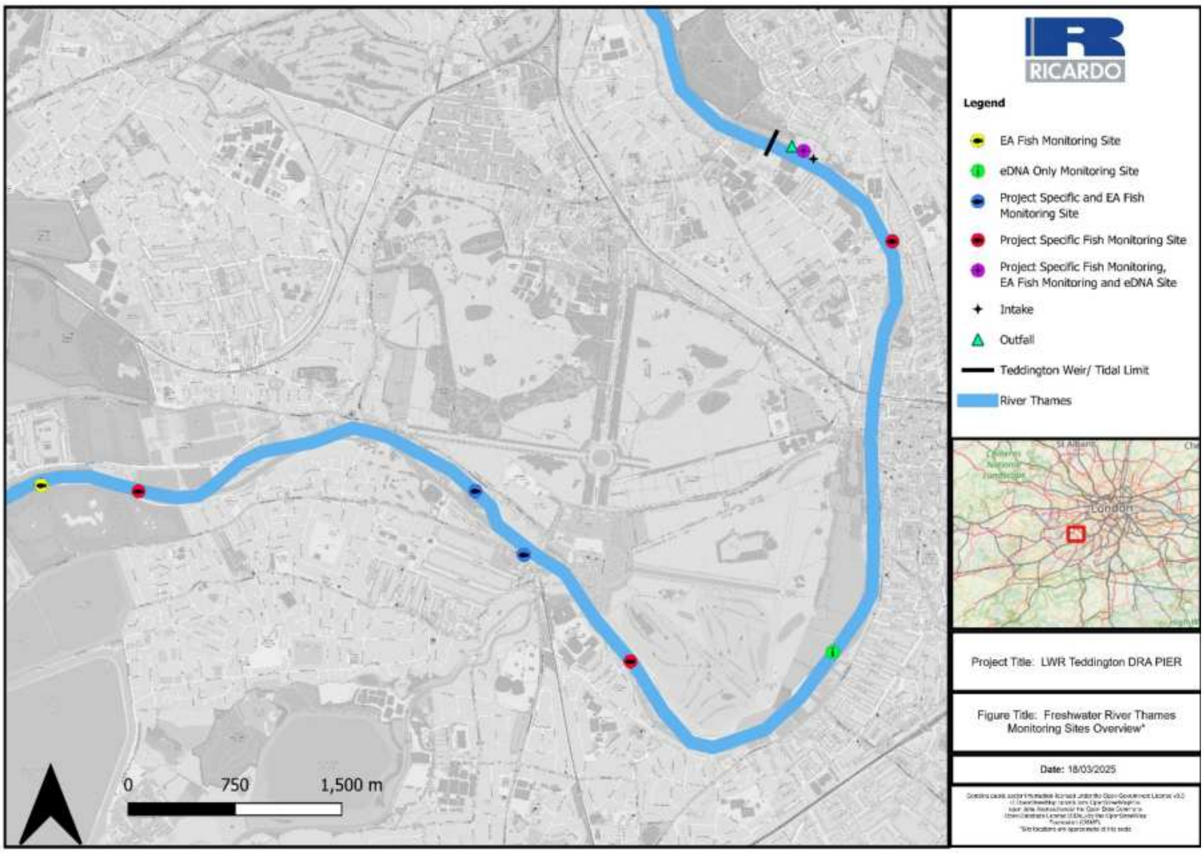
b. Targeted monitoring:

i. APEM Ltd, on behalf of Atkins, undertook fish monitoring surveys (juvenile seine netting and electric fishing) in autumn, 2021 and 2022.

[16] Jacobs UK Limited (2024) J698-AJ-C02B-TEDD-RP-EN-100003 Fisheries Consolidated Report.
[17] Ricardo (2022). London Effluent Reuse SRO – Annex B.2.3: Fish Assessment Report ED13591. Report for Thames Water Utilities Ltd. Classification: CONFIDENTIAL

ii. Ricardo, on behalf of Thames Water, undertook fish monitoring surveys (juvenile seine netting, electric fishing and eDNA) in the summer/ autumn of 2023.

Plate A.60 A map of fish monitoring locations within the freshwater River Thames



A.2.162 The EA and project-specific fisheries monitoring data indicate that the fish community within this reach is diverse and representative of the dominant habitat, which is a slow-flowing glide on a large lowland river at the fringe of the tidal limit. The fisheries monitoring programme follows UK[18] and EA guidance[19].

A.2.163 Several species dominate the fish community, in most years contributing to ~95% of the reported total abundance. The top seven species are listed below in bulked rank order (i.e., via totalling all data from 2010 to 2023) within Table A.20. Migratory species of note were also recorded within the reach and include European eel (*Anguilla anguilla*) from across a range of life stages, including adults and elvers, (although no glass eels were recorded), with predominantly adult individuals represented (0.73% of community composition; total length range: 110 mm to 1,100 mm), brown/sea trout (n = 7; fork length range: 225 mm to 554 mm), Atlantic salmon (n = 2; fork length range: 640 mm to 768 mm) and lamprey species (n = 3; total length range: 130 mm to 160 mm). A time-series stacked histogram indicating the percentage of catch abundance by species is presented in Plate A.64. A density plot of species abundance by site

[18] British Standards Institution (2006) BS EN 14962:2006, BS 6068-5.40:2006: Water quality. Guidance on the scope and selection of fish sampling methods, London: BSI.
[19] EA Operational Instructions (OI's) for netting, electrofishing and sampling eel populations in rivers

and over time, categorised by their individual tolerance for environmental changes assigned under the Fisheries Classification Scheme 2 (FCS2)[20], is provided in Table A.20 The reach is predominately comprised of fish with high and moderate tolerance, while low-tolerance fish occur rarely. These accompanying data visualisations indicate the community composition and show the dominant and less frequently occurring fish species that populate the lower reaches of the freshwater River Thames. These displays combine all of the Ricardo, APEM, and EA data, as well as a range of methodologies including electric-fishing and seine netting to help alleviate biases/limitations of individual techniques and provide a complete overview of species presence. An overview of the species size class distributions within the freshwater River Thames is provided in Table A.20.

A.2.164 Less frequent is the occurrence of species (including INNS of interest[*]) such as tench (*Tinca tinca*), common barbel (*Barbus barbus*), common bream (*Abramis brama*), common carp (*Cyprinus carpio*), mirror carp (*C. carpio carpio*), *grass carp (*Ctenopharyngodon idella*), *zander (*Sander lucioperca*), Eurasian ruffe (*Gymnocephalus cernua*), European flounder (*Platichthys flesus*), 3-spined stickleback (*Gasterosteus aculeatus*), common rudd (*Scardinius erythrophthalmus*), European bullhead (*Cottus gobio*), stone loach (*Barbatula barbatula*), and Eurasian minnow (*Phoxinus phoxinus*). European eel, brown/ sea trout (*Salmo trutta*), Atlantic salmon (*Salmo salar*) and lamprey species (*Lampetra* spp.) have also been recorded within this reach.

Table A.20 Dominant fish species within the freshwater River Thames, listed in rank-bulked order. Note: Length statistics have been calculated from a sub-sampled population of the total catch from combined monitoring survey data completed by the EA, Ricardo, and APEM (on behalf of Atkins) from 2010 to 2023. No data is available for 2017 (likely owing to limited resourcing) and 2020 (Covid-19)

Rank order	Species	% Community Composition	Total sub-sample measured (*n*)	Max. fork length (mm)	Min. fork length (mm)	Median fork length (mm)	± standard deviation
1	Common roach (*Rutilus rutilus*) (inc. hybrids)	39.88	991	300	15	58.0	43.5
2	Common bleak (*Alburnus alburnus*)	19.46	671	128	15	68.0	26.0
3	Common dace	13.66	354	216	20	72.0	33.0

[20] WFD-UKTAG. (2008). UKTAG Rivers Assessment Methods Fish Fauna. Fisheries Classification Scheme 2 (FCS2).

Rank order	Species	% Community Composition	Total sub-sample measured (*n*)	Max. fork length (mm)	Min. fork length (mm)	Median fork length (mm)	± standard deviation
	(*Leuciscus leuciscus*)						
4	Perch (*Perca fluviatilis*)	5.88	292	437	20	117.0	72.85
5	Gudgeon (*Gobio gobio*)	3.60	213	140	18	109.0	21.0
6	Common chub (*Squalius cephalus*)	1.93	135	550	40	478.0	178.69
7	Northern pike (*Esox lucius*)	1.55	73	1010	190	660.0	189.0

A.2.165 Migratory species such as Atlantic salmon, sea trout, and European eel utilise the fish pass, elver pass, and weir structure at Teddington to facilitate their migratory phase. It is not known if European river lamprey (*Lampetra fluviatilis*) migrate through the fish pass at Teddington Weir. EA records suggest that there are low numbers of *Lampetra sp*. present within the freshwater River Thames, however eDNA sampling undertaken at the Project intake location did not detect any *Lampetra sp*. The fish pass at Teddington Weir (located along the left hand bank of the weir) is considered to be impassable to twaite shad (*Alosa fallax*), given that the original design and specification of the Denil fish pass was to facilitate the upstream migration of Atlantic salmon. There is no evidence to suggest that sea lamprey (*Petromyzon marinus*) or European smelt (*Osmerus eperlanus*) access the freshwater reach of the River Thames, nor indeed that they ever accessed this reach of the River Thames since the construction of Teddington Weir in 1811. Indeed, until 2022, the same has been assumed for twaite shad. However, a summer 2023 eDNA detection for *Alosa sp*. at the Project's intake location (TQ 17235 71341) suggests that some individuals may be able to enter the freshwater River Thames (perhaps under appropriate tidal/flow conditions and approach timings at Teddington Weir). The eDNA results are available in Table A.21 where results are displayed as a percentage representing the proportion of the DNA from that sample attributed to each species. While sequence read proportions are influenced by taxon abundance, they do not provide a direct measure of abundance. Other factors such as biomass, activity, surface area, condition, proximity to the sampling site, primer bias, and species-specific genomic variation also affect the proportion of sequence reads observed. It should also be noted that the potential for fish pass upgrades within the next decade at Teddington Weir may provide these species with an accessible route into the freshwater reaches of the River Thames.

Table A.21 Fish eDNA sampling results from water samples collected at the proposed Teddington DRA intake location within the River Thames in 2023.

Species	July 2023	September 2023
European eel	2.81%	0.91%
Alosa sp.	0.24%	-
Common bream	9.21%	3.93%
Common bleak	0.45%	9.47%
Common barbel	0.03%	-
Silver bream	0.03%	-
Cyprinus sp.	0.16%	0.04%
Gudgeon	0.09%	-
Common dace	0.65%	1.03%
Leuciscus sp.	-	1.96%
Eurasian minnow	3.25%	0.02%
Roach	27.76%	64.50%
Common chub	33.89%	9.98%
Tench	0.06%	-
Stone loach	0.05%	-
Barbatula sp.	0.28%	0.08%
Northern pike	0.10%	0.08%
Three-spined stickleback	1.78%	-
European seabass	0.14%	-
Eurasian ruffe	3.31%	0.88%
European perch	14.48%	-
European Flounder	-	7.02%
Brown trout	0.04%	-
Cottus sp.	1.21%	0.11%

A.2.166 Juvenile fish surveys were undertaken directly upstream (~750 m) of the Project intake location (site: LTOA Ham Road) on the River Thames (NGR: TQ1791870560 to TQ 17810 70820). Size class and fork length frequency distributions of a sub-sample of fish species captured during surveys completed in the summer/autumn of October 2021 (electric fishing and seine netting), September 2022 (seine netting) and September 2023 (seine netting at the LTOA Ham Road site are presented in Table A.22,Plate A.61 and Plate A.62.

Table A.22 Fish species captured at LTOA Ham Road during monitoring surveys completed in 2021, 2022 and 2023

Rank order	Species	Total(t)/ sub-sample(s) measured (n)	Max. fork length (mm)	Min. fork length (mm)
1	**Common roach** (*Rutilus rutilus*)	$125_{(s)}$	142	15
2	**Perch** (*Perca fluviatilis*)	$71_{(t)}$	192	40
3	**Common dace** (*Leuciscus leuciscus*)	$53_{(s)}$	82	29
4	**Common bleak** (*Alburnus alburnus*)	$50_{(s)}$	88	31
5	**European eel** (*Anguilla anguilla*)	$4_{(t)}$	900	300
6	**Eurasian ruffe** (*Gymnocephalus cernua*)	$4_{(t)}$	85	75
7	**Common bream** (*Abramis brama*)	$3_{(t)}$	49	36
8	**European bullhead** (*Cottus gobio*)	$1_{(t)}$	60	60
9	**Common chub** (*Squalius cephalus*)	$2_{(t)}$	130	42
10	**Eurasian minnow** (*Phoxinus phoxinus*)	$1_{(t)}$	32	32
11	**Northern pike** (*Esox lucius*)	$1_{(t)}$	260	260

Plate A.61 Size class distribution (including median, maximum, minimum, and interquartile ranges) of species captured 750 m upstream of the proposed Teddington DRA location (site: LTOA Ham Road), within a 300 m section of the freshwater River Thames (NGRs: TQ1791870560 to TQ 17810 70820) via a juvenile seine netting and electrofishing surveys completed on 5th September 2023, 8th September 2022 and 21st October 2021. Note: data represents sub-sampled population ($n_{sub\text{-}sampled}$ = 315; n_{total} = 2,255).

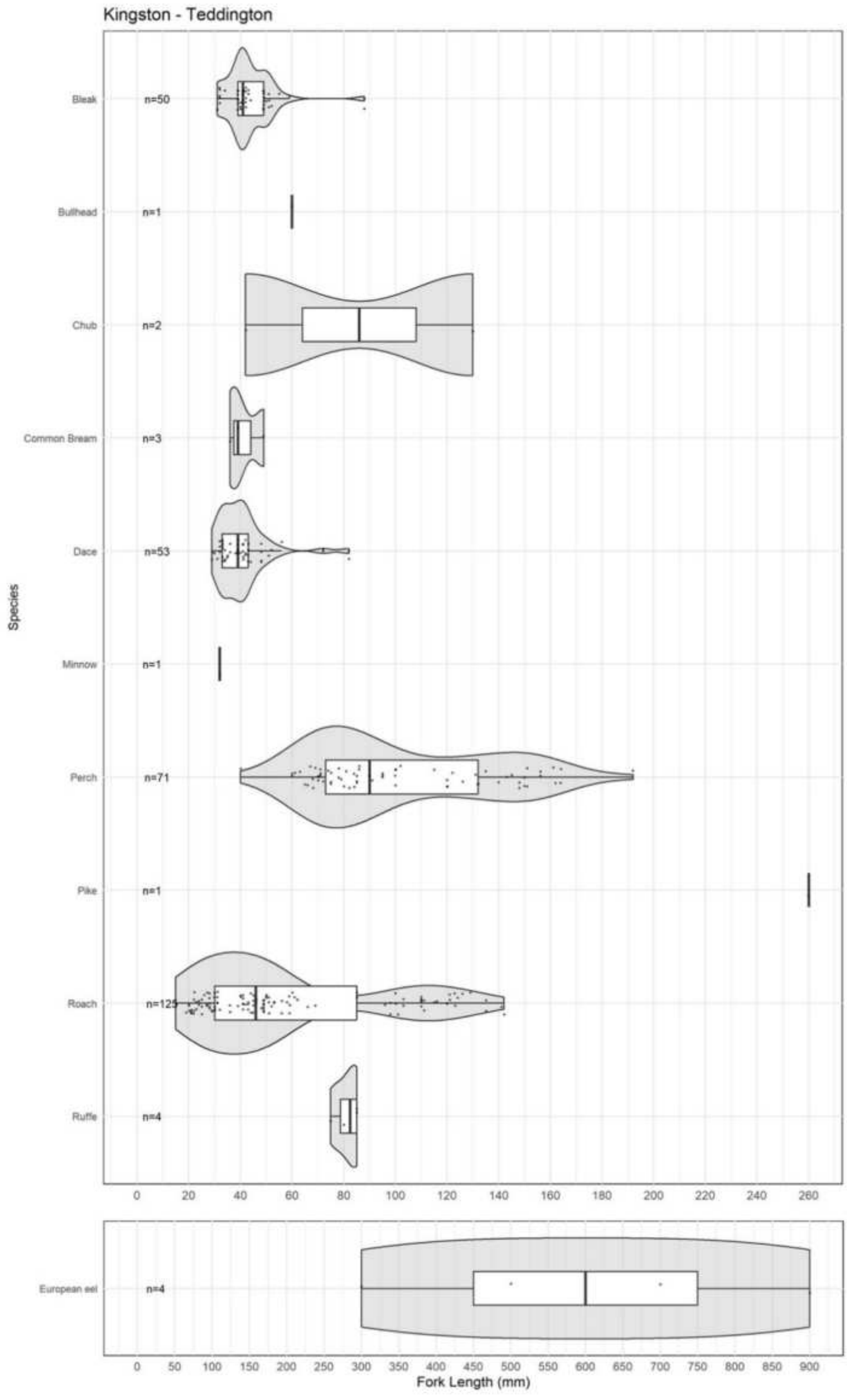
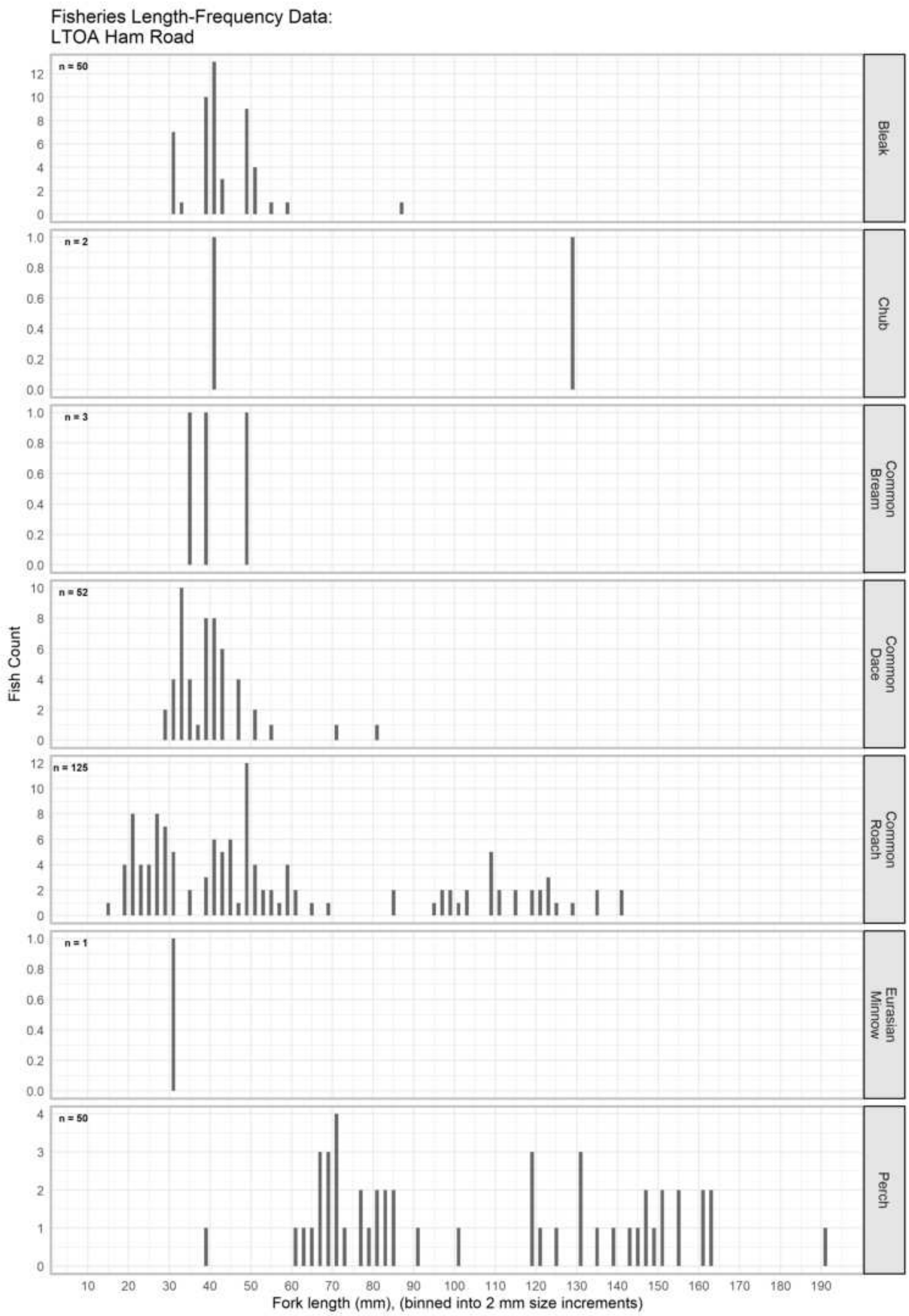


Plate A.62 Fork length frequency distribution of species captured 750 m upstream of the proposed Teddington DRA location (site: LTOA Ham Road), within the freshwater River Thames (NGR: TQ1791870560 to TQ 17810 70820) via juvenile seine netting survey completed on 5th September 2023 and 8th September 2022. Note: data represents the sub-sampled population ($n_{sub\text{-}sampled}$ = 224; n_{total} = 2196)[21].



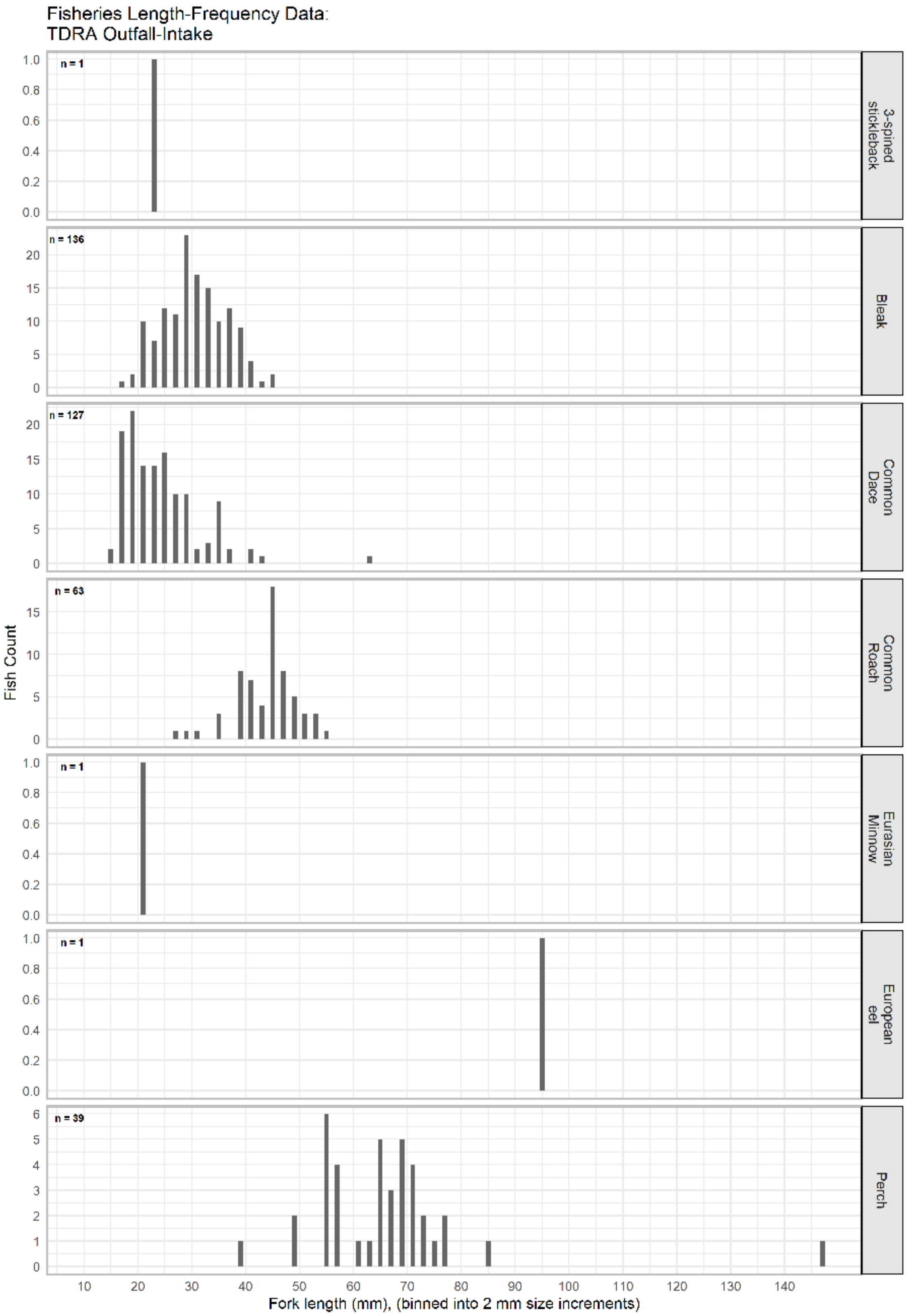
[21] While fish population surveys were completed at LTOA Ham Road site in 2021 by APEM on behalf of Atkins, juvenile seine netting efforts only captured a total of four individuals, with the remainder of the 2021 survey completed via an electric fishing methodology. As the electric fishing method used in 2021 will predominantly have targeted the larger adult individuals, rather than juvenile populations within the reach, this data has not been incorporated into Plate A.61.

A.2.167 Targeted fish surveys were undertaken on 08 August 2024 at the Project intake/outfall location using a juvenile seine netting methodology. Bleak were the most abundant species caught followed by common dace and common roach. Other species caught include perch, European eel, Eurasian minnow and 3-spined stickleback. Fish community compositions at this site can be seen in Table A.23 and Plate A.63 shows the size classes of all species caught.

Table A.23 Fish species captured at the Project intake/outfall location during monitoring surveys completed in 2024

Rank order	Species	Total fish captured	Number of Fish measured	Max. fork length (mm)	Min. fork length (mm)
1	**Bleak** **(***Alburnus alburnus***)**	1108	136	18	45
2	**Common dace** (*Leuciscus leuciscus*)	530	127	15	64
3	**Common roach** (*Rutilus rutilus*)	293	63	28	55
4	**Perch** (*Perca fluviatilis*)	39	39	40	147
5	**European eel** (*Anguilla anguilla*)	1	1	95	95
6	**Eurasian minnow** (*Phoxinus phoxinus*)	1	1	21	21
7	**3-Spined Stickleback** (*Gasterosteus aculeatus*)	1	1	24	24

Plate A.63 Fork length frequency distribution of species captured at the proposed Teddington DRA intake and outfall location within the freshwater River Thames via juvenile seine netting survey completed on 8th August 2024. Note: data represents the sub-sampled population ($n_{sub\text{-}sampled}$ = 368; n_{total} = 1973).



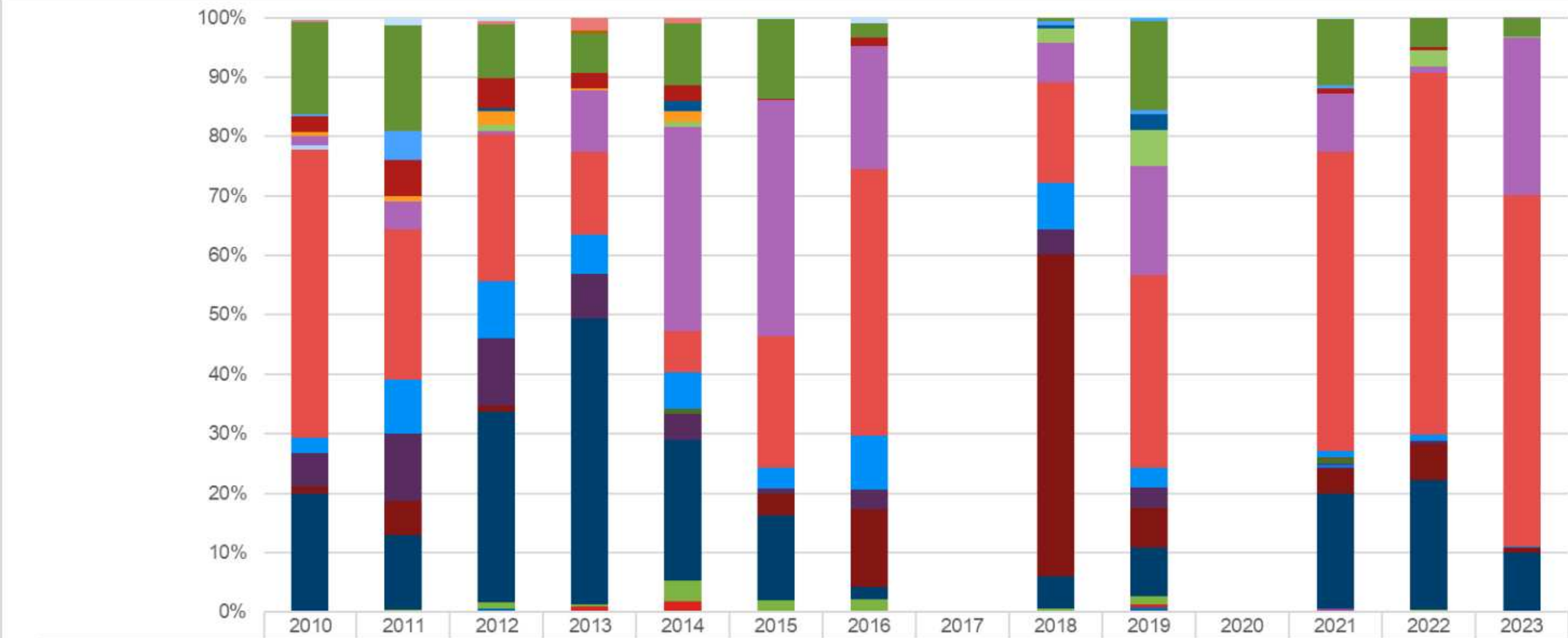
A.2.168 The constraints within the complete dataset should be noted, owing to limitations associated with the catch per unit effort (CPUE), timed-sample electric fishing and juvenile seine netting methods utilised within the reach of interest[22]. Sampling of an unconstrained reach tends to lead to inherent biases towards weak swimming fish within reported data outputs. The available monitoring datasets have been gathered using a range of different methods considered to be best practice across different years. As such, this will provide a complete overview of the presence of species within the reach. The general community composition is shown in Table A.24, but given the associated constraints, this may be an under or misrepresentation of the full species composition. Indeed, at the LTOA Ham Road site, ~ 750 m upstream of the Project's intake location, European eel are represented in the 2021 dataset but not the 2023 dataset, likely owing to differences in sampling methodologies. Surveys in 2023 used the micromesh juvenile seine netting methodology only, while in 2021, surveys included both seine and electric fishing sampling methodologies, with European eel captured via electric fishing only.

A.2.169 In addition to seine netting and electric fishing data for this section of the Freshwater River Thames, adjacent to the Project's intake location, eDNA surveys were completed, with results from two samples collected in summer 2023 (July and September, respectively). Fish eDNA suite (water sampling) provides a complementary, non-intrusive broad-spectrum indication of species present within the sampling location or from nearby locations upstream. Results are presented as a proportion (in this instance, equating to a percentage) of the total eDNA extracted from each sample in Table A.21. While this cannot provide the overall population sizes of the species recorded, it indicates the relative proportions of species within the fish community at the sample site. Results are comparable to species recorded using seine and electric fishing methods in 2022 and 2023. However, additional species (and genus, when recovered eDNA could not be identified to species level) were detected in the reach using the eDNA methodology, providing a more complete understanding of the overall fish community composition. An additional 11 fish species and/or genera were detected using eDNA sampling within this section of the freshwater River Thames, including *Alosa sp.*, common barbel, silver bream, *Cyprinus sp.*, gudgeon, tench, stone loach, three-spined stickleback, European seabass, European flounder, and brown/sea trout.

A.2.170 In summary, the fish population found within the freshwater River Thames is rich and diverse, it is primarily made up of a mixture of species with a High and Medium tolerance to environmental change (as classified under FCS2) with Low tolerance species occurring rarely. It has a mix of coarse and estuarine species, including diadromous migratory species, as would be expected for a large lowland river on the fringe of the tidal limit. Available water depth and velocity requirements for the differing life stages of fish species noted within the freshwater River Thames are described in further detail within Table A.35.

[22] National Programme on Technology Enhanced Learning (2012) Fish Sampling Methods in Rivers, Lakes, Reservoirs etc… Retrieved from: https://archive.nptel.ac.in/courses/120/108/120108002/

Plate A.64 Thames Water Walton Intake to Teddington Weir, fisheries monitoring data represented as the proportion of species recorded within the total annual reported catch abundance. Note: this includes combined monitoring survey data completed by the EA, Ricardo, and APEM (on behalf of Atkins) from 2010 to 2023



	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Sea Bass	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.05%
Flounder	0.37%	1.30%	0.56%	0.00%	0.00%	0.22%	0.86%	0.00%	0.00%	0.00%	0.00%	0.18%	0.00%	0.05%
Zander	0.37%	0.00%	0.56%	2.20%	0.88%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Grass carp	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.68%	0.00%	0.00%	0.00%	0.00%
30spined stickleback	0.00%	0.00%	0.00%	0.44%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Perch	15.56%	17.83%	8.99%	6.61%	10.53%	13.38%	2.59%	0.00%	0.60%	14.86%	0.00%	11.27%	5.02%	3.05%
European elver	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.03%
European eels > elvers	0.37%	4.78%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.60%	0.68%	0.00%	0.55%	0.00%	0.05%
European eel	2.59%	6.09%	5.06%	2.64%	2.63%	0.22%	1.29%	0.00%	0.00%	0.00%	0.00%	0.73%	0.47%	0.00%
Common carp varieties	0.00%	0.00%	0.56%	0.00%	1.75%	0.00%	0.00%	0.00%	0.60%	2.70%	0.00%	0.00%	0.00%	0.00%
Common [wild] carp	0.74%	0.87%	2.25%	0.44%	1.75%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Common bream	0.00%	0.00%	1.12%	0.00%	0.88%	0.00%	0.00%	0.00%	2.41%	6.08%	0.00%	0.00%	2.82%	0.18%
Bleak	1.48%	4.78%	0.56%	10.13%	34.21%	39.69%	20.69%	0.00%	6.63%	18.24%	0.00%	9.82%	0.94%	26.41%
Tench	0.74%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Roach	48.52%	25.22%	24.72%	14.10%	7.02%	22.15%	44.83%	0.00%	16.87%	32.43%	0.00%	50.36%	60.97%	59.09%
Chub	2.59%	9.13%	9.55%	6.61%	6.14%	3.51%	9.05%	0.00%	7.83%	3.38%	0.00%	1.09%	0.94%	0.16%
Stone loach	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.18%	0.00%	0.03%
Ruffe	0.00%	0.00%	0.00%	0.00%	0.88%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.91%	0.00%	0.00%
Pike	5.56%	11.30%	11.24%	7.49%	4.39%	0.88%	3.45%	0.00%	4.22%	3.38%	0.00%	0.18%	0.47%	0.00%
Minnow	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.36%	0.00%	0.03%
Gudgeon	1.11%	5.65%	1.12%	0.00%	0.00%	3.73%	12.93%	0.00%	54.22%	6.76%	0.00%	4.36%	6.11%	0.81%
Dace	20.00%	12.61%	32.02%	48.02%	23.68%	14.25%	2.16%	0.00%	5.42%	8.11%	0.00%	19.45%	21.79%	9.91%
Rudd	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Barbel	0.00%	0.43%	1.12%	0.44%	3.51%	1.97%	2.16%	0.00%	0.60%	1.35%	0.00%	0.00%	0.31%	0.03%
Bullhead	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.36%	0.00%	0.05%
Lamprey sp.	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.08%
Brown/sea trout	0.00%	0.00%	0.00%	0.88%	1.75%	0.00%	0.00%	0.00%	0.00%	0.68%	0.00%	0.18%	0.16%	0.00%
Atlantic salmon	0.00%	0.00%	0.56%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.68%	0.00%	0.00%	0.00%	0.00%

Table A.24 Fish monitoring data indicating community composition and species densities at sites within the freshwater River Thames. Data has been merged into three zonal regions within the freshwater River Thames (Kingston to Teddington; Molesey to Kingston; and Walton to Molesey) for the period 2010 to 2023. Note: fish species are categorised according to individual tolerance (low, moderate, high or unclassified) to environmental change (for example, flow, temperature, water quality) as defined under FCS2[23]. This includes combined monitoring survey data completed by the EA, Ricardo, and APEM (on behalf of Atkins) from 2010 to 2023. No data is available for 2017 and 2020.

SPECIES BY TOLERANCE (2010 – 2023)																													
	Year	Low tolerance				Moderate tolerance									High tolerance											Unclassified tolerance			
		Atlantic salmon	Brown/sea trout	Lamprey sp.	Bullhead	Barbel	Rudd	Dace	Gudgeon	Minnow	Pike	Ruffe	Stone loach	Chub	Roach	Tench	Bleak	Common bream	Common [wild] carp	Common carp varieties	European eel	European eels > elvers	European elver	Perch	3-spined stickleback	Grass carp	Zander	Flounder	Sea Bass
Walton-Molesey	2010	-	-	-	-	-	-	54	3	-	15	-	-	7	131	2	4	-	2	-	7	1	-	42	-	-	1	1	-
	2011	-	-	-	-	1	-	29	13	-	26	-	-	21	58	-	11	-	2	-	14	11	-	41	-	-	-	3	-
	2012	1	-	-	-	2	-	57	2	-	20	-	-	17	44	-	1	2	4	1	9	-	-	16	-	-	1	1	-
	2013	-	2	-	-	1	-	109	-	-	17	-	-	15	32	-	23	-	1	-	6	-	-	15	1	-	5	-	-
	2014	-	2	-	-	4	-	27	-	-	5	1	-	7	8	-	39	1	2	2	3	-	-	12	-	-	1	-	-
	2015	-	-	-	-	9	-	65	17	-	4	-	-	16	101	-	181	-	-	-	1	-	-	61	-	-	-	1	-
	2016	-	-	-	-	5	-	5	30	-	8	-	-	21	104	-	48	-	-	-	3	-	-	6	-	-	-	2	-
	2018	-	-	-	-	1	-	9	90	-	7	-	-	13	28	-	11	4	-	1	-	1	-	1	-	-	-	-	-
	2019	1	1	-	-	2	-	12	10	-	5	-	-	5	48	-	27	9	-	4	-	1	-	22	-	1	-	-	-
	2021	-	-	-	1	-	-	8	-	2	-	1	1	-	31	-	3	-	-	-	-	3	-	34	-	-	-	-	-
	2022		1	-	-	2	-	130	39	-	3	-	-	3	324	-	6	18	-	-	3	-	-	16	-	-	-	-	-
	2023	-	-	3	2	1	-	73	31	-	-	-	1	5	535	-	880	4	-	-	-	2	1	68	-	-	-	2	2
Molesey - Kingsto	2021	-	1	-	-	-	-	98	24	-	-	-	-	6	246	-	51	-	-	-	-	-	-	7	-	-	-	1	-
	2022	-	-	-	-	-	-	9	-	-	-	-	-	2	9	-	-	-	-	-	-	-	-	14	-	-	-	-	-
Kingston-Teddington	2021	-	-	-	1	-	-	1	-	-	1	4	-	-	-	-	-	-	-	-	4	-	-	21	-	-	-	-	-
	2022	-	-	-	-	-	-	-	-	-	-	-	-	1	56	-	-	-	-	-	-	-	-	2	-	-	-	-	-
	2023	-	-	-	-	-	-	304	-	1	-	-	-	1	1714	-	125	3	-	-	-	-	-	48	-	-	-	-	-

Density key (number of fish)

1 to 5
6 to 15
16 to 30
31 to 50
51 to 100
101 to 500
500 +

[23] WFD-UKTAG. (2008). UKTAG Rivers Assessment Methods Fish Fauna. Fisheries Classification Scheme 2 (FCS2).

Table A.25 Fish species captured within the freshwater River Thames and their size class distributions.

Species	Total sub-sample measured (*n*)	Max. fork length (mm)	Min. fork length (mm)	Median fork length (mm)	± standard deviation
Atlantic Salmon (*Salmo Salar)*	2	768	640	704.0	226.4
Barbel (*Barbus barbus*)	28	760	80	619	226.4
Common Bleak (*Alburnus alburnus*)	671	128	15	68.0	26.0
Common Bream (*Abramis brama*)	57	535	36	425	115.3
Brown/Sea Trout (*Salmo trutta*)	8	554	225	422.5	106.6
European Bullhead (*Cottus gobio*)	4	60	42	47	8.0
Common Carp (inc. varieties)	18	770	566	662.5	57.9
Common Chub (*Squalius cephalus*)	135	550	40	478.0	178.7
Common Dace (*Leuciscus leuciscus*)	354	216	20	72.0	33.0
Common Roach (*Rutilus rutilus*) (inc. hybrids)	991	300	15	58.0	43.5
European Eel (*Anguilla anguilla*)	46	1100	110	635	228.3
Flounder (*Platichthys flesus*)	11	320	89	196	79.1
Grass Carp (*Ctenopharyngodon idella*)	1	520	520	520	n/a
Gudgeon (*Gobio gobio*)	213	140	18	109.0	21.0
Lamprey sp. (*Lampetra sp.*)	3	160	130	158	16.8

Species	Total sub-sample measured (*n*)	Max. fork length (mm)	Min. fork length (mm)	Median fork length (mm)	± standard deviation
Minnow (*Phoxinus Phoxinus*)	3	65	32	55	16.9
Northern pike (*Esox lucius*)	73	1010	190	660.0	189.0
Perch (*Perca fluviatilis*)	292	437	20	117.0	72.9
Ruffe (*Gymnocephalus cernua*)	6	105	75	85	10.6
Seabass (*Dicentrarchus labrax*)	1	91	91	91	n/a
Stone loach (*Barbatula barbatula*)	2	95	56	75.5	27.6
Tench (*Tinca tinca*)	1	490	490	490	n/a
Thin-lipped Grey Mullet (*Chelon ramada*)	1	530	530	530	n/a
Zander (*Sander lucioperca*)	8	730	106	149	294.2

Tidal River Thames (Teddington Weir to Battersea)

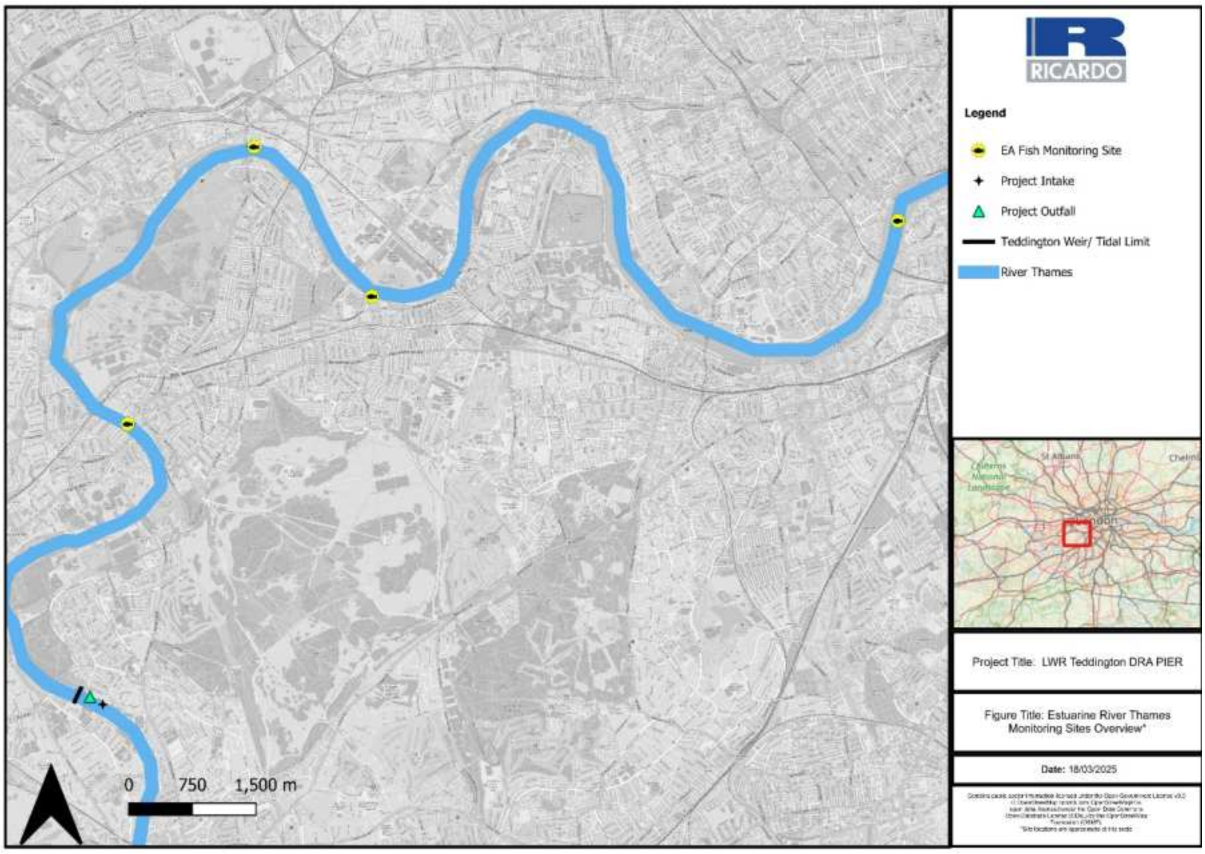
A.2.171 A total of 89 fisheries surveys across four sites (Table A.26) constitute the baseline dataset for the Tidal River Thames, with all the data represented by EA monitoring.

Table A.26 shows the full list of fish site locations used to establish the baseline for the freshwater and tidal River Thames

Study Area	Site Names	NGR
Thames Tideway	Richmond	TQ1760074600
	Kew	TQ1909377873
	Chiswick	TQ2048476107
	Battersea	TQ2670077000

A.2.172 The full dataset for the Thames Tideway from Teddington Weir to Battersea has been obtained from NFPD and includes transitional and coastal (TRaC) fish counts for all species for all areas and all years (2010 – 2023). The EA undertakes this monitoring work.

Plate A.65 A map of fish monitoring locations within the Thames Tideway



A.2.173 Several fish species dominate the fish community within the Thames Tideway in most years, contributing to ~95% of the reported total abundance. The top 10 are listed in bulked rank order (i.e., via totalling all data from 2020 to 2023) within Table A.27. A time-series stacked histogram indicating the percentage of catch abundance by species is presented in Plate A.66.

Table A.27 Dominant fish species within the Thames Tideway, listed in rank-bulked order. Note: Length statistics have been calculated from a sub-sampled population of the total catch during EA surveys (beam trawl, kick netting, and seine netting methodologies) completed between 2010 and 2023. No data is available for 2020, likely due to the COVID-19 pandemic

Rank order	Species	% Community Composition	Total sub-sample measured (*n*)	Max. fork length (mm)	Min. fork length (mm)	Median fork length (mm)	± standard deviation
1	**Common dace** (*Leuciscus leuciscus*)	27.73	2244	220	11	76	33.30
2	**European flounder** (*Platichthys flesus*)	26.94	4042	338	5	27	25.93
3	**Common roach** (*Rutilus rutilus*)	23.41	1199	254	22	62	28.11
4	**Common goby** (*Pomatoschistus microps*)	5.55	1369	80	16	40	5.55
5	**Sea bass** (*Dicentrarchus labrax*)	5.47	873	360	17	61	21.36
6	**European smelt** (*Osmerus eperlanus*)	4.78	780	185	14	61	23.10
7	**Common bream** (*Abramis brama*)	2.56	408	557	38	73	93.38
8	**Common bleak** (*Alburnus alburnus*)	0.53	117	147	34	55	24.87
9	**3-spined stickleback** (*Gasterosteus aculeatus*)	0.45	96	55	16	34.5	7.38
10	**European eel** (*Anguilla anguilla*)	0.43	104	700	40	128	136.62

A.2.174 The EA fisheries monitoring data indicate that the fish community within this reach is predominantly freshwater in nature, but the transitional nature of the tidal River Thames (Upper Tideway) is also reflected, with an increase in the total abundance of estuarine and marine juvenile species.

A.2.175 While a shift in abundance is apparent, and the overall freshwater and marine species diversity differs throughout the Thames Tideway.

c. (Richmond: $n_{freshwater\ species} = 16$; $n_{marine\ species} = 6$;

d. Kew: $n_{freshwater\ species} = 16$; $n_{marine\ species} = 8$;

e. Chiswick: $n_{freshwater\ species} = 12$; $n_{marine\ species} = 10$; and

f. Battersea: $n_{freshwater\ species} = 15$; $n_{marine\ species} = 7$).

A.2.176 Table A.27 shows a density plot of the graded change in the fish community composition by site and over time. This moves from a predominantly freshwater-abundant fish assemblage at Richmond (near the tidal limit at Teddington Weir) and progressively transitions into a more estuarine-dominant community downriver, towards Battersea Park.

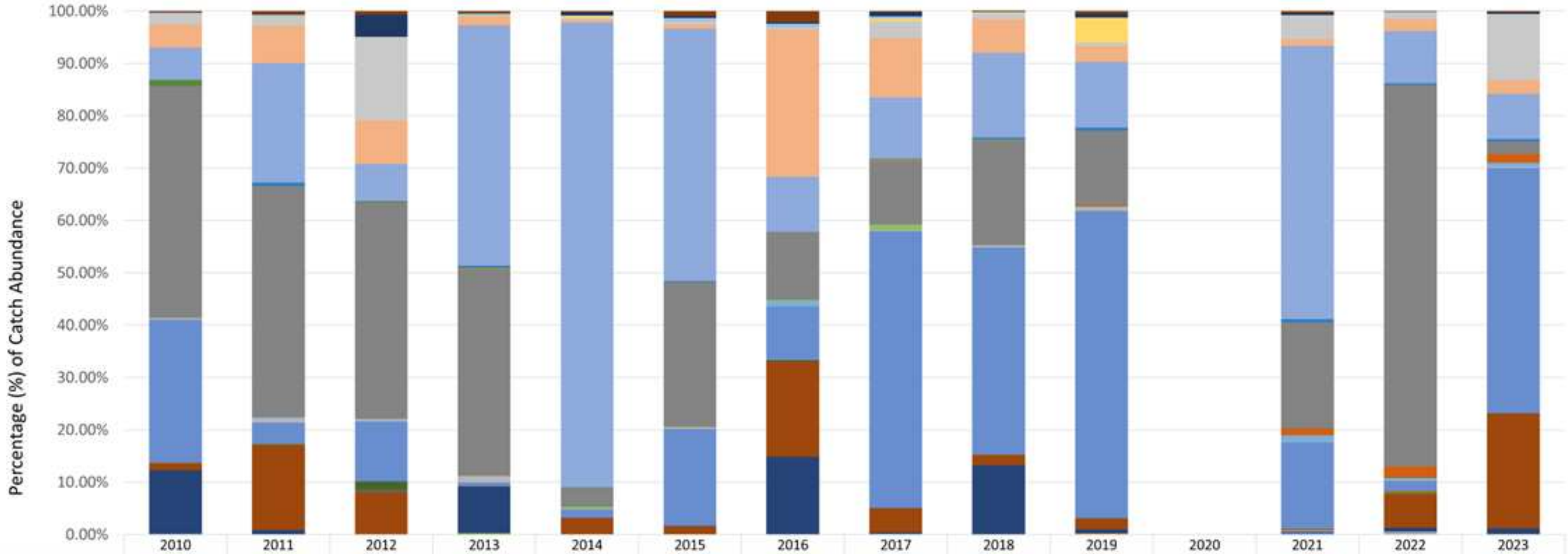
A.2.177 At the farthest up-river EA site within the Thames Tideway, Richmond (located 5 km downstream of Teddington Weir), the catch abundance is dominated by common dace and common roach, which account for an average of 46.03% and 38.99% of the total yearly catch abundance, respectively. Less frequent is the occurrence of other species typical of freshwater rivers, such as common chub (0.8%), common bream (0.2%), bullhead (0.2%), and gudgeon (0.4%). While the majority of the fish community at this site is composed of species typical of a freshwater river, many estuarine fish species are also represented. These include flounder (8.3%), European smelt (<0.01%), sea bass (2.7%), common goby (1.3%), and sand smelt (0.02%). On average, marine species account for <15% of annual catch abundance. However, several years record notably higher abundances of estuarine/ marine species, such as in 2010, where flounder accounted for approximately 18.4% of the catch abundance, and in 2016, where sea bass composed approximately 28% of the total catch at the Richmond site. European eel and one record of brown trout (in 2013) have also been documented at this site.

A.2.178 At Kew, the second most up-river site, located 10km downstream of Teddington Weir, the catch abundance indicates a transition toward a estuarine-dominant community in comparison to Richmond. Flounder are the most frequently captured species at Kew, making up 32% of the catch abundance. Sea bass and common goby also account for a large portion of the catch abundance at this site, comprising 15.7% and 8.8% of the data, respectively. European smelt at this site account for a lower proportion of the catch, at 3.3%. Some freshwater species abundances remain relatively high at the site, with common dace and common roach making up 15.4% and 14% of the catch, respectively. Less frequent are the occurrence of other species typical of freshwater rivers, for example, common bleak (1.8%), common bream (4.3%), bullhead (0.43%), and gudgeon (0.05%). While there is still a high prevalence of species typical of a freshwater watercourse at Kew, including records of European eel, on average, marine species account for over 60% of the annual catch abundance at this site. That said, the proportion of freshwater species was greater in 2013, where, for example, common dace made up 31.3% of the total catch abundance.

A.2.179 Moving progressively farther downriver, at the Chiswick and Battersea sites, located 12 km and 22 km downstream of Teddington Weir, respectively, the fish communities continue a progression toward a species assemblage indicative of estuarine environments. Marine species at Chiswick account for >75% of the catch abundance at Chiswick, with smelt catch particularly dominant at the site in 2018, where the species accounted for 48.6% of the total catch. Marine species at the Battersea site accounted for >85% of the catch abundance. At both sites, freshwater species remain present, albeit they contribute to a much smaller proportion, with species including common roach, common bream, common dace, perch (*Perca fluviatilis*), and 3-spined stickleback recorded over most survey years.

A.2.180 The accompanying data visualizations below indicate the dominant and less frequently occurring fish species that populate the varying community compositions present within the Thames Tideway. An overview of the species size class distributions within the Thames Tideway is provided in Table A.24.

Plate A.66 Teddington Weir to Battersea Park fisheries monitoring data represented as the proportion of species recorded within the total annual reported catch abundance. Note: the table includes monitoring survey data completed by the EA from 2010 to 2023



	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
3-spined stickleback	0.22%	0.69%	0.74%	0.30%	0.27%	0.96%	2.11%	0.28%	0.03%	0.52%		0.41%	0.08%	0.26%
Bleak	0.13%	0.00%	4.20%	0.15%	0.62%	0.36%	0.30%	0.72%	0.15%	0.70%		0.41%	0.08%	0.26%
Brown / sea trout	0.00%	0.00%	0.00%	0.15%	0.00%	0.00%	0.00%	0.06%	0.00%	0.00%		0.00%	0.00%	0.00%
Bullhead	0.09%	0.56%	0.08%	0.15%	0.04%	0.66%	0.70%	0.44%	0.00%	0.00%		0.00%	0.00%	0.00%
Chub	0.00%	0.14%	0.08%	0.00%	0.39%	0.00%	0.00%	0.50%	0.24%	4.82%		0.00%	0.00%	0.00%
Common bream	2.12%	1.44%	15.83%	0.23%	0.35%	0.66%	0.50%	3.21%	1.25%	0.70%		4.60%	1.37%	12.74%
Common goby	4.41%	7.13%	8.33%	1.81%	0.54%	0.78%	28.04%	11.33%	6.35%	3.02%		1.22%	2.34%	2.60%
Dace	6.19%	22.78%	7.01%	45.90%	88.81%	48.21%	10.55%	11.66%	16.16%	12.54%		52.23%	9.93%	8.58%
European eel	1.21%	0.00%	0.25%	0.00%	0.04%	0.06%	0.00%	0.00%	0.00%	0.00%		0.00%	0.00%	0.00%
European eels > elvers	0.00%	0.74%	0.00%	0.38%	0.00%	0.12%	0.00%	0.22%	0.36%	0.58%		0.68%	0.32%	0.52%
European elvers	0.00%	0.00%	0.00%	0.15%	0.04%	0.00%	0.00%	0.22%	0.06%	0.00%		0.00%	0.00%	0.00%
Flounder	44.27%	44.12%	41.38%	39.58%	3.58%	27.72%	12.96%	12.11%	20.17%	14.11%		20.16%	72.88%	2.34%
Goby sp.	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.29%		1.35%	2.10%	1.69%
Grey mullet sp.	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%		0.00%	0.08%	0.00%
Gudgeon	0.00%	0.05%	0.00%	0.00%	0.47%	0.00%	0.30%	1.16%	0.03%	0.12%		0.00%	0.08%	0.00%
Minnow	0.04%	0.14%	0.00%	0.00%	0.00%	0.00%	1.01%	0.00%	0.00%	0.17%		1.22%	0.08%	0.78%
Mirror carp	0.00%	0.00%	0.00%	0.00%	0.00%	0.06%	0.00%	0.00%	0.00%	0.00%		0.00%	0.00%	0.00%
Perch	0.26%	0.83%	0.49%	1.28%	0.12%	0.24%	0.00%	0.11%	0.36%	0.64%		0.14%	0.32%	0.26%
Pike	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.06%	0.03%	0.00%		0.00%	0.00%	0.00%
Roach	27.35%	4.07%	11.46%	0.68%	1.55%	18.52%	10.25%	52.90%	39.59%	58.59%		16.51%	2.02%	46.81%
Roach x common bream hybrid	0.00%	0.00%	1.57%	0.00%	0.00%	0.00%	0.20%	0.00%	0.00%	0.00%		0.00%	0.00%	0.00%
Rudd	0.00%	0.00%	0.00%	0.00%	0.04%	0.06%	0.00%	0.00%	0.00%	0.00%		0.00%	0.00%	0.00%
Sand goby	0.09%	0.14%	0.08%	0.00%	0.00%	0.00%	0.00%	0.00%	0.06%	0.06%		0.00%	0.56%	0.00%
Sand smelt	0.00%	0.09%	0.41%	0.00%	0.00%	0.00%	0.00%	0.06%	0.06%	0.17%		0.00%	0.16%	0.00%
Sea bass	1.34%	16.25%	8.08%	0.08%	3.11%	1.55%	18.19%	4.53%	1.93%	1.97%		0.27%	6.30%	21.98%
Smelt	12.16%	0.83%	0.00%	8.88%	0.00%	0.06%	14.87%	0.33%	13.17%	0.75%		0.00%	0.73%	1.04%
Sprat	0.00%	0.00%	0.00%	0.23%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%		0.00%	0.00%	0.00%
Stickleback sp.	0.13%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%		0.00%	0.08%	0.00%
Stone loach	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%		0.14%	0.00%	0.00%
Thick lipped grey mullet	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.11%	0.00%	0.00%		0.00%	0.48%	0.00%
Thin lipped grey mullet	0.00%	0.00%	0.00%	0.00%	0.04%	0.00%	0.00%	0.00%	0.00%	0.23%		0.00%	0.00%	0.00%
Zander	0.00%	0.00%	0.00%	0.08%	0.00%	0.00%	0.00%	0.00%	0.03%	0.00%		0.68%	0.00%	0.13%

Table A.28 Fish monitoring data indicating community composition and species densities at sites within the upper Thames Tideway (tidal River Thames). Data is displayed for four sites surveyed within the Thames Tideway (Richmond; Kew; Chiswick, and Battersea) for the period 2010 to 2023. Note: fish species are categorised according to community assemblage (freshwater or marine). The table includes combined survey data completed by the EA from 2010 to 2022 via beam trawl, kick sampling, and seine netting methodologies. No data is available for 2020

SPECIES ABUNDANCE BY ASSEMBLAGE (2010 – 2022)																															
ZONE	YEAR	Freshwater Fish Community																				Estuarine Fish Community										
		Brown/ sea trout	European eel	European eels > elvers	European elver	Bleak	Bullhead	Chub	Common bream	Dace	Gudgeon	Minnow	Mirror carp	Perch	Pike	Roach	Roach x common bream hybrid	Rudd	3-spined stickleback	Stickleback sp.	Stone loach	Zander	Common goby	Sand goby	Goby sp.	Flounder	Sand smelt	Sea bass	Smelt	Sprat	Grey mullet sp.	Thick lipped grey mullet	Thin lipped grey mullet
Richmond	2010	-	1	-	-	2	2	-	1	101	-	1	-	2	-	615	-	-	-	3	-	-	16	-	-	169	-	6	-	-	-	-	-
	2011	-	-	-	-	-	5	2	-	473	-	3	-	2	-	59	-	-	1	-	-	-	25	-	-	155	-	7	1	-	-	-	-
	2012	-	1	-	-	-	1	-	-	2	-	-	-	-	-	-	-	-	1	-	-	-	2	-	-	38	1	1	-	-	-	-	-
	2013	1	-	-	-	-	1	-	-	365	-	-	-	4	-	8	-	-	-	-	-	-	12	-	-	93	-	-	-	-	-	-	-
	2014	-	-	-	-	-	1	10	8	2077	11	-	-	1	-	31	-	1	-	-	-	-	3	-	-	5	-	27	-	-	-	-	-
	2015	-	-	1	-	1	6	-	1	634	-	-	1	1	-	288	-	-	4	-	-	-	4	-	-	19	-	4	-	-	-	-	-
	2016	-	-	-	-	-	-	-	-	88	3	10	-	-	-	74	-	-	12	-	-	-	41	-	-	-	-	87	-	-	-	-	-
	2017	-	-	-	-	7	2	7	5	201	21	-	-	-	-	884	-	-	-	-	-	-	-	-	-	96	-	8	-	-	-	-	-
	2018	-	-	-	-	1	-	4	3	475	1	-	-	1	-	1101	-	-	-	-	-	-	16	-	-	97	-	2	-	-	-	-	-
	2019	-	-	1	-	1	-	64	-	177	2	3	-	7	-	986	-	-	3	-	-	-	15	-	5	128	-	-	-	-	-	-	-
	2021	-	-	-	-	3	-	-	-	342	-	9	-	1	-	119	-	-	3	-	-	-	7	-	-	-	-	-	-	-	-	-	-
	2022	-	-	-	-	-	-	-	1	109	1	1	-	-	-	18	-	-	-	-	-	-	-	-	24	124	1	13	-	-	-	-	-
Kew	2010	-	12	-	-	1	-	-	3	38	-	-	-	2	-	2	-	-	4	-	-	-	63	-	-	179	-	23	14	-	-	-	-
	2011	-	-	11	-	-	6	1	19	18	1	-	-	15	-	24	-	-	12	-	-	-	62	-	-	111	1	327	4	-	-	-	-
	2012	-	1	-	-	48	-	-	10	79	-	-	-	6	-	64	-	-	4	-	-	-	23	1	-	27	2	42	-	-	-	-	-
	2013	-	-	1	-	-	1	-	1	182	-	-	-	12	-	-	-	-	2	-	-	-	2	-	-	203	-	-	5	-	-	-	-
	2014	-	-	-	-	13	-	-	-	96	1	-	-	1	-	4	-	-	3	-	-	-	5	-	-	12	-	20	-	-	-	-	-
	2015	-	-	-	-	2	4	-	4	128	-	-	-	1	-	18	-	-	8	-	-	-	1	-	-	79	-	9	-	-	-	-	-
	2016	-	-	-	-	2	2	-	1	1	-	-	-	-	-	5	-	-	4	-	-	-	14	-	-	25	-	55	-	-	-	-	-
	2017	-	-	2	3	2	5	1	20	4	-	-	-	2	1	53	-	-	5	-	-	-	95	-	-	45	1	45	-	-	-	2	-
	2018	-	-	2	-	3	-	-	16	37	-	-	-	6	-	185	-	-	-	-	-	1	77	-	-	369	-	45	115	-	-	-	-
	2019	-	-	1	-	1	-	15	4	5	-	-	-	3	-	5	-	-	1	-	-	-	10	1	-	26	1	29	1	-	-	-	-
	2021	-	-	-	-	-	-	-	-	41	-	-	-	-	-	-	-	-	-	-	1	-	2	-	4	-	-	-	-	-	-	-	-
	2022	-	-	1	-	1	-	-	10	4	-	-	-	1	-	6	-	-	-	1	-	-	10	-	-	257	1	36	-	-	-	6	-

SPECIES ABUNDANCE BY ASSEMBLAGE (2010 – 2022)																															
ZONE	YEAR	Freshwater Fish Community																				Estuarine Fish Community										
		Brown/ sea trout	European eel	European eels > elvers	European elver	Bleak	Bullhead	Chub	Common bream	Dace	Gudgeon	Minnow	Mirror carp	Perch	Pike	Roach	Roach x common bream hybrid	Rudd	3-spined stickleback	Stickleback sp.	Stone loach	Zander	Common goby	Sand goby	Goby sp.	Flounder	Sand smelt	Sea bass	Smelt	Sprat	Grey mullet sp.	Thick lipped grey mullet	Thin lipped grey mullet
Chiswick	2010	-	9	-	-	-	-	-	5	4	-	-	-	-	-	6	-	-	1	-	-	-	12	2	-	177	-	1	127	-	-	-	-
	2011	-	-	4	-	-	1	-	5	1	-	-	-	1	-	-	-	-	2	-	-	-	25	2	-	110	-	12	1	-	-	-	-
	2012	-	-	-	-	2	-	-	1	2	-	-	-	-	-	4	-	-	1	-	-	-	20	-	-	35	-	47	-	-	-	-	-
	2013	1	-	2	-	2	-	-	2	60	-	-	-	1	-	1	-	-	1	-	-	-	4	-	-	68	-	1	95	3	-	-	-
	2014	-	1	-	-	3	-	-	-	100	-	-	-	-	-	3	-	-	-	-	-	-	5	-	-	21	-	31	-	-	-	-	1
	2015	-	-	-	-	3	-	-	2	41	-	-	-	1	-	2	-	-	4	-	-	-	-	-	-	110	-	8	-	-	-	-	-
	2016	-	-	-	-	1	4	-	2	16	-	-	-	-	-	21	-	-	2	-	-	-	150	-	-	53	-	36	2	-	-	-	-
	2017	-	-	1	-	4	-	1	17	5	-	-	-	-	-	16	-	-	-	-	-	-	74	-	-	37	-	25	-	-	-	-	-
	2018	-	-	9	-	-	-	3	17	16	-	-	-	2	1	34	-	-	-	-	-	-	44	-	-	81	-	14	209	-	-	-	-
	2019	-	-	5	-	10	-	4	4	34	-	-	-	1	-	15	-	-	4	-	-	-	12	-	-	29	1	5	3	-	-	-	4
	2021	-	-	1	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6	6	-	2	-	-	-	-	-
	2022	-	-	1	-	-	-	-	4	9	-	-	-	2	-	1	-	-	1	-	-	-	4	-	2	98	-	25	1	-	1	-	-
Battersea	2010	-	6	-	-	-	-	-	40	-	-	-	-	2	-	9	-	-	-	-	-	-	11	-	-	495	-	1	130	-	-	-	-
	2011	-	-	1	-	-	-	-	7	-	-	-	-	-	-	5	-	-	-	-	-	-	42	1	-	576	1	5	12	-	-	-	-
	2012	-	1	-	-	1	-	1	181	2	-	-	-	-	-	71	19	-	2	-	-	-	56	-	-	402	2	6	-	-	-	-	-
	2013	-	-	1	2	-	-	-		3	-	-	-	-	-	-	-	-	-	-	-	1	6	-	-	163	-	-	18	-	-	-	-
	2014	-	-	-	1	-	-	-	1	12	-	-	-	1	-	2	-	-	4	-	-	-	1	-	-	56	-	2	-	-	-	-	-
	2015	-	1	1	-	-	1	-	4	4	-	-	-	1	-	2	-	1	-	-	-	-	8	-	-	256	-	5	1	-	-	-	-
	2016	-	-	-	-	-	1	-	2	-	-	-	-	-	-	2	2	-	3	-	-	-	74	-	-	51	-	2	146	-	-	-	-
	2017	1	-	1	1	-	1	-	16	1	-	-	-	-	-	4	-	-	-	-	-	-	36	-	-	41	-	4	6	-	-	-	-
	2018	-	-	1	2	1	-	1	6	17	-	-	-	3	-	15	-	-	1	-	-	-	77	2	-	133	2	4	120	-	-	-	-
	2019	-	-	3	-	-	-	-	4	-	-	-	-	-	-	3	-	-	1	-	-	-	15	-	-	60	1	-	9	-	-	-	-
	2021	-	-	4	-	-	-	-	34	1	-	-	-	-	-	3	-	-	-	-	-	5	-	-	-	143	-	-	-	-	-	-	-
	2022	-	-	2	-	-	-	-	2	1	-	-	-	1	-	-	-	-	-	-	-	-	15	7	-	414	-	4	8	-	-	-	-

SPECIES ABUNDANCE BY ASSEMBLAGE (2010 – 2022)																																	
ZONE	YEAR	Freshwater Fish Community																					Estuarine Fish Community										
		Brown/ sea trout	European eel	European eels > elvers	European elver	Bleak	Bullhead	Chub	Common bream	Dace	Gudgeon	Minnow	Mirror carp	Perch	Pike	Roach	Roach x common bream hybrid	Rudd	3-spined stickleback	Stickleback sp.	Stone loach	Zander	Common goby	Sand goby	Goby sp.	Flounder	Sand smelt	Sea bass	Smelt	Sprat	Grey mullet sp.	Thick lipped grey mullet	Thin lipped grey mullet

Density key (number of fish)

- 1 to 5
- 6 to 15
- 16 to 30
- 31 to 50
- 51 to 100
- 101 to 500
- 500 +

Table A.29 Fish species captured within the Thames Tideway (Teddington Weir to Battersea) and their size class distributions

Species	Total sub-sample measured (*n*)	Max. fork length (mm)	Min. fork length (mm)	Median fork length (mm)	± standard deviation
3-Spined Stickleback (*Gasterosteus aculeatus*)	96	55	16	34.5	7.4
Common Bleak (*Alburnus alburnus*)	117	147	34	55	24.9
Common Bream (*Abramis brama*)	408	557	38	73	93.4
Brown/Sea Trout (*Salmo trutta*)	3	416	249	249	96.4
European Bullhead (*Cottus gobio*)	44	81	12	39.5	15.1
Common Chub (*Squalius cephalus*)	114	105	13	37	17.1
Common Dace (*Leuciscus leuciscus*)	2244	220	11	76	33.3
Common Roach (*Rutilus rutilus*) (inc. hybrids)	1390	254	22	62	27.9
European Eel (*Anguilla anguilla*)	33	650	72	130	139.9
European Eels > Elvers (*Anguilla anguilla*)	62	700	40	132	141.1
European Elvers (*Anguilla anguilla*)	9	110	60	90	14.7
Flounder (*Platichthys flesus*)	4042	338	5	27	25.9
Goby sp. (*Gobio sp.*)	54	46	17	32	6.2
Grey Mullet sp. ()	1	23	23	23	n/a
Gudgeon (*Gobio gobio*)	41	146	42	69	23.3

Species	Total sub-sample measured (*n*)	Max. fork length (mm)	Min. fork length (mm)	Median fork length (mm)	± standard deviation
Minnow (*Phoxinus Phoxinus*)	33	63	38	46	6.5
Mirror Carp (*Cyprinus carpio*)	1	610	610	610	n/a
Northern pike (*Esox lucius*)	2	630	84	357	386.1
Perch (*Perca fluviatilis*)	86	245	21	45	51.4
Rudd (*Scardinius erythrophthalmus*)	2	65	44	54.5	14.8
Sand Goby (*Pomatoschistus minutus*)	16	63	38	51	7.5
Sand Smelt (*Atherina presbyter*)	15	92	45	56	13.5
Sea bass (*Dicentrarchus labrax*)	873	360	17	61	21.4
Smelt (*Osmerus eperlanus*	780	185	14	61	23.1
Sprat (*Sprattus sprattus*)	3	113	97	99	8.7
Stickleback sp. (*Gasteroseidae sp.*)	4	37	31	35	3
Stone loach (*Barbatula barbatula*)	1	52	52	52	n/a
Thick-lipped Grey Mullet (*Chelon labrosus*)	8	125	21	31.5	44.7
Thin-lipped Grey Mullet (*Chelon ramada*)	5	48	21	42	10.6
Zander (*Sander lucioperca*)	8	565	30	86	179.6

Key Diadromous Fish Species

A.2.181 As evidenced from the data within the sections above, the River Thames is used by a number of migratory fish species, including:

g. European Eel

h. Atlantic Salmon

i. Brown/ sea trout

j. River Lamprey

k. Sea Lamprey

l. European Smelt

m. Twaite Shad

A.2.182 These migratory fish species have complex life cycles, often with multiple stages, including freshwater and seaward migrations, alongside juvenile imprinting phases (Table A.32). Migratory species use a range of cues, including olfaction[24][25], water temperature[26], dissolved oxygen[27] and other physico-chemical parrameters, river flow (discharge volume)[28], tidal state, and lunar phase,[29] to trigger and navigate migrations.

A.2.183 The extent to which these species use the Thames catchment is dependent upon passability for fish and the presence of suitable spawning habitat. A review of the available open-source data collected by the EA during freshwater and TRaC surveys was completed for the entirety of the Thames River Basin District, with baseline data presented for the freshwater River Thames and Thames Tideway within the sections above. As earlier noted, while the fish pass at Teddington is considered impassable to twaite shad, a summer 2023 eDNA detection for *Alosa sp*. at the proposed Teddington DRA intake location suggests that some individuals may be able to enter the freshwater River Thames (perhaps under appropriate tidal conditions, river flows, and approach timings at Teddington Weir). There is, however, no evidence to suggest that sea lamprey or European smelt currently enter the freshwater reach of the River Thames. Regardless, details on these important migratory species have been included below, both given the potential for future fish pass development at Teddington Weir within the next decade that could potentially expand the home

[24] Hara, T. J. (1975). Olfaction in fish. Progress in Neurobiology. 5 (4), pp. 271-335.
[25] Stabell, O.B., 1984. Homing and olfaction in salmonids: a critical review with special reference to the Atlantic salmon. Biological Reviews, 59(3), pp. 333-388.
[26] Jonsson, N. (1991). Influence of water flow, water temperature and light on fish migrations in rivers. Nord J Freshw Res. 66. pp. 20-35.
[27] Maes J, Stevens M, & Breine J. (2007). Modelling the migration opportunities of diadromous fish species along a gradient of dissolved oxygen concentration in a European tidal watershed. Estuarine Coastal and Shelf Science, 75, pp. 151-162.
[28] Milner, N.J., Solomon, D.J. and Smith, G.W. (2012). The role of river flow in the migration of adult Atlantic salmon, Salmo salar, through estuaries and rivers. Fisheries Management and Ecology, 2012, 19, pp. 537–547.
[29] Cresci, A., Sandvik, A.D., Sævik, P.N., Ådlandsvik, B., Olascoaga, M.J., Miron, P., Durif, C.M.F., Skiftesvik, A.B., Browman, H.I., & Vikebø, F. (2021). The lunar compass of European glass eels (*Anguilla anguilla*) increases the probability that they recruit to North Sea coasts. Fisheries Oceanography. 30, pp. 315-330.

range of these fish species within the Thames Catchment and owing to their known presence within the Thames Tideway.

European eel

A.2.184 The European eel is an IUCN red list critically endangered species and is listed as a Species of Principal Importance under the Natural Environments and Rural Communities Act (2006). The River Thames is an important river basin district for European eel, particularly migrating elvers, with the highest numbers being recorded in the major tributaries of the Thames.

A.2.185 The European eel is a facultative catadromous fish species with a complex life history[30]. Downstream adult migration usually occurs during autumn (September to December), when adults migrate from predominantly freshwater reaches and migrate a distance of >5000 km, returning to spawning areas in the Sargasso Sea[31]. After spawning, larvae (leptocephalus) drift across the Atlantic Ocean using the Gulf Stream towards the European continental shelf, which takes approximately 10 months to two years, depending on ocean currents[32]. Upon arrival, larvae undergo metamorphosis in response to increased light levels, transforming into ‘glass eel’, after which, in response to a range of environmental cues (for example, temperature, salinity, flow, diel, tidal phases, and olfactory stimulants[29]), they navigate toward coastal and estuarine habitats, with the majority migrating upstream into freshwater catchments[30,33]. By the time individuals have reached freshwater, they have developed to elvers[34,35]. Juvenile eel grow to maturity over several years before silvering from its yellow form and completing a downstream migration back to the sea from September to December as ‘silver eel’. Following maturation, this adult migration is triggered by lunar activity, temperature, rainfall, and increased river flow (discharge volume).

A.2.186 Elver migration within the Thames takes place from April until September each year, with a typical peak movement observed in July, August and September. Yearly fluctuations are common as migration is dependent on environmental

[30] Durif, C.M.F., Arts, M., Bertolini, F., Cresci, A., Daverat, F., Karlsbakk, E., Koprivnikar, J., Moland, E., Olsen, E.M., Parzanini, C., Power, M., Rohtla, M., Skiftesvik, A.B., Thorstad, E., Vøllestad, L.A., and Browman, H.I. (2023). The evolving story of catadromy in the European eel (Anguilla anguilla). ICES Journal of Marine Science. 0, pp. 1-13.
[31] Wright, R.M., Piper, A.T., Aarestrup, K., Azevedo, J.M.N., Cowan, G., Don, A., Gollock, M., Rodriguez Ramallo, S., Velterop, R., Walker, A., Westerberg, H. and Righton, D. (2022). First direct evidence of adult European eels migrating to their breeding place in the Sargasso Sea. *Scientific Reports*. 12, pp. 15362.
[32] Bonhommeau, S., Blanke, B., Treguier, A. M., Grima, N., Rivot, E., Vermard, Y., Eric, G. and Le Pape, O. (2009). How fast can the European eel (Anguilla anguilla) cross the Atlantic Ocean. Fisheries Oceanography (1054-6006) (Wiley / Blackwell), 2009-10 , Vol. 18 , N. 6 , P. 371-385. 18.
[33] Boardman, R.M., Pinder, A.C., Piper, A.T. , Gutmann Roberts C, Wright RM and & Britton JR (2024) Variability in the duration and timing of the estuarine to freshwater transition of critically endangered European eel Anguilla anguilla. Aquatic Science 86, 18
[34] Boardman, R.M., Pinder, A.C., Piper, A.T. , Gutmann Roberts C, Wright RM and & Britton JR (2024) Variability in the duration and timing of the estuarine to freshwater transition of critically endangered European eel Anguilla anguilla. Aquatic Science 86, 18
[35] Harrison AJ, Walker AM, Pinder AC, Briand C & Aprahamian MW (2014) A review of glass eel migratory behaviour, sampling techniques and abundance estimates in estuaries: implications for assessing recruitment, local production and Exploitation. Reviews in Fish Biology and Fisheries 24: 967–983.

triggers[36]. The triggers include reaching a daily temperature fluctuation between 10°C and 14°C for juvenile eel, or exceeding 15°C for elver, and following a new moon[37,38]. Temperatures of 10–11°C have been demonstrated as a critical threshold for pigmented elvers ascending weir or sluice barriers[39]. It is reported that glass eel move up the estuary using selective tidal stream transport (STST), whereby the eels utilise the flood tide to move inland. During the ebb tide, they move into areas with the least velocity in the benthic and littoral zones in order to maximise the distance travelled relative to the energy used[40]. Modelling indicates that transit time in the Tidal River Thames from the London Gateway port to the River Brent is approximately 11 days. If a diel strategy (daylight avoidance) for predator avoidance during daytime is factored in, then transit time increases to approximately 14 days[41]. However, it is noted that elvers may stay and feed within the estuary during their migration[42] and that the upstream migration of eels from tidal habitats to freshwater is not uniform[43].

A.2.187 European eel are present within the Thames River basin district, with the species recorded at 276 sites throughout the catchment within both freshwater and transitional waterbodies. Eel are recorded in several upland streams a significant distance from the tidal River Thames, including at the River Churn close to the western edge of the catchment. Though eel are recorded throughout the catchment, the highest densities of individuals are typically recorded within major tributaries of the River Thames within the lower catchment. Sites which record the highest frequency of European eel are located within the River Wandle, River Ash, River Roding, Chetney Marshes, River Hogsmill, River Lee, River Wey, River Thames, River Colne, River Medway, River Darent, Mardyke and Fobbing Catchment and Beverley Brook.

Eel Trapping Data

A.2.188 The EA has supplied eel trapping data, which has been used to assess the periods during which eels migrate to the Thames. It noted that the data was collected by the Zoological Society of London (ZSL) using citizen scientists. The

[36] Boardman, R.M., Pinder, A.C., Piper, A.T, Gutmann Roberts C, Wright RM and & Britton JR (2024) Environmental influences on the phenology of immigrating juvenile eels over weirs at the tidal limit of regulated rivers Hydrobiologia 851 4439-4458

[37] Naismith, I.A., and Knights, B. (1988). Migrations of elvers and juvenile European eels, *Anguilla anguilla* L. in the River Thames. J. Fish. Biol. 33 (Supplement A.), pp. 161-175.

[38] Boardman, R.M., Pinder, A.C., Piper, A.T, Gutmann Roberts C, Wright RM and & Britton JR (2024) Variability in the duration and timing of the estuarine to freshwater transition of critically endangered European eel Anguilla anguilla. Aquatic Science 86, 18

[39] White EM and Knights B (1997) Dynamics of upstream migration of the European eel, Anguilla anguilla (L.), in the Rivers Severn and Avon, England, with special reference to the effects of man-made barriers Fisheries Management and Ecology 4(4) 311-324

[40] Piper A.T., Wright R.M. and Kemp P.S. (2012) The influence of attraction flow on upstream passage of European eel (*Anguilla anguilla*) at intertidal barriers, Ecological Engineering, Volume 44 329-336

[41] Benson T, de Bie J, Gaskell J, Vezza P, Kerr JR, Lumbroso D, Owen MR, Paul S. Kemp PS (2021) Agent-based modelling of juvenile eel migration via selective tidal stream transport, Ecological Modelling 443

[42] Boardman, R.M., Pinder, A.C., Piper, A.T, Gutmann Roberts C, Wright RM and & Britton JR (2024) Variability in the duration and timing of the estuarine to freshwater transition of critically endangered European eel Anguilla anguilla. Aquatic Science 86, 18

[43] Boardman, R.M., Pinder, A.C., Piper, A.T, Gutmann Roberts C, Wright RM and & Britton JR (2024) Variability in the duration and timing of the estuarine to freshwater transition of critically endangered European eel Anguilla anguilla. Aquatic Science 86, 18

data source indicates that traps are set up covering the “traditional” eel migration window, which is from the end of April to the end of September each year.

a. Teddington Weir eels trapping (2014 to 2019)

b. Molesey weir eels trapping (2013 to 2019 and 2022)

c. Stoney Sluices on the River Brent eels trapping (2013 to 2018)

A.2.189 Plate A.67 shows the total count of eels caught by the ZSL between 2013 and 2022. Stoney sluice on the River Brent had a significantly higher total count compared to Teddington Weir and Molesey Weir on the River Thames. Stoney sluice on the River Brent caught the most eels of all the available datasets from ZSL and was stopped after 2018 due to welfare concerns, as so many eels were being trapped at this site[44].

A.2.190 Correspondence with the EA confirmed that the trap at Teddington was in a poor location and was then replaced by an eel pass where trapping was not possible. This is likely to explain the low numbers caught at Teddington throughout the survey period, with only 150 eels caught on 52 out of 235 survey days. The count data at Molesey was significantly higher than at Teddington throughout the survey period. Molesey is located upstream of Teddington on the River Thames, which further indicates that eels were migrating past Teddington but were not caught in the trap, as opposed to being absent.

A.2.191 The EA has also suggested that the trap at Molesey was not in a good position, and it was likely that many eels migrated past the weir without being caught by the trap. This may explain why Molesey had lower counts compared to Stoney sluice on the River Brent. Data from 2020 and 2021 is absent for all the sites due to COVID-19 restrictions preventing the trapping from taking place. Total counts from each trap can be seen in Plate A.67.

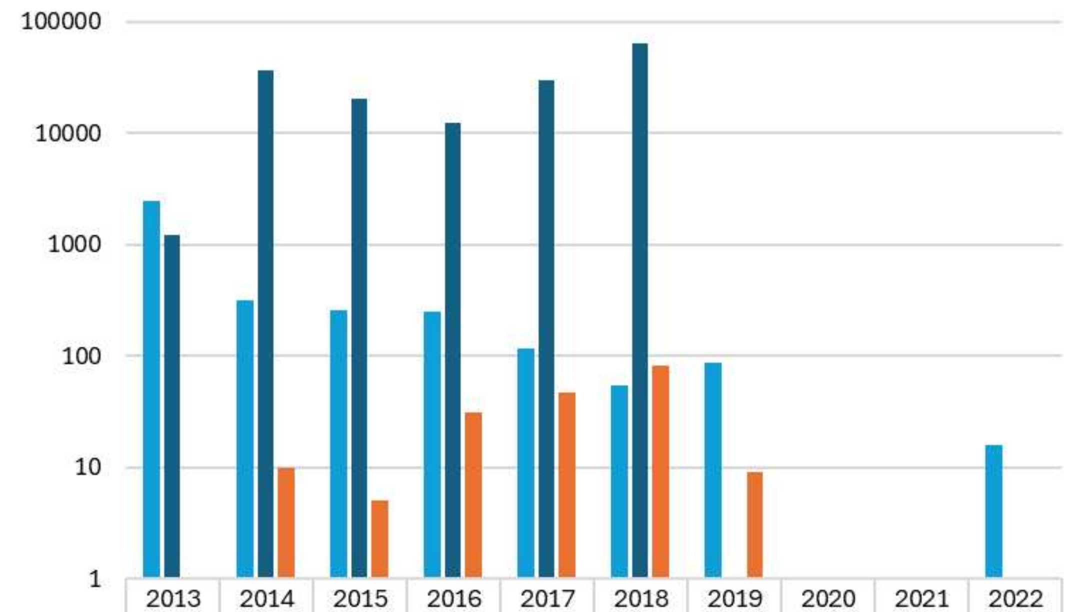
A.2.192 Size class data from the eel traps showed the vast majority of eels trapped were recently recruited elvers at less than 160mm in length[45] Plate A.67. Only small numbers of eel were caught at Teddington, all of which were less than 120mm long. At Molesey, the majority of eels caught were between 70mm and 120mm in length.

A.2.193 At the River Brent, the majority of individuals were between 80 and 120mm. On the River Brent, a small number (approximately 576 of the 165,633) of individuals caught were longer than 160mm. It may be that these individuals are slightly older, or it could be that these individuals are still recently recruited but are slightly larger than average.

[44] Email correspondence from the Environment Agency (May 2024)

[45] Size classes from Laffaille et al. (2004) Habitat preferences of different European eel size classes in a reclaimed marsh: a contribution to species and ecosystem conservation. Wetlands 24 (3) 642-651

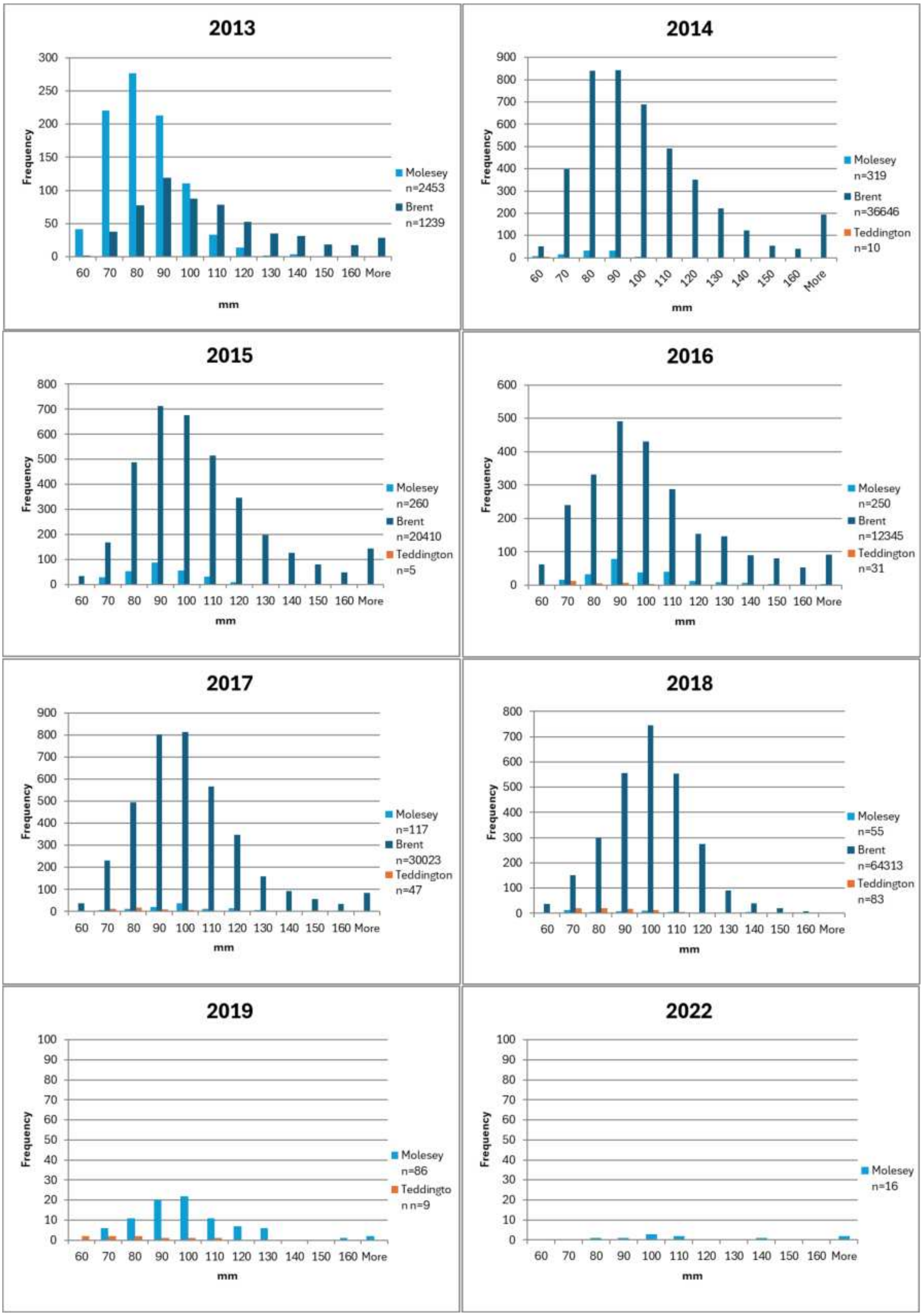
Plate A.67 Total eel counts from all three sites from 2013 - 2022 on a logarithmic scale



	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Molesey	2453	319	260	250	117	55	86			16
Brent	1239	36646	20410	12345	30023	64313				
Teddington		10	5	31	47	83	9			

Note: - The Molesey eel trap was not monitored in 2020 and 2021. The River Brent eel trap was not monitored *after 2018*. Teddington eel trap was not monitored *after 2019*.

Plate A.68 Histograms showing the frequency of elver lengths in 10mm increments caught in eel trapping undertaken between 2013 – 2022 on the River Brent and the River Thames at Molesey and Teddington



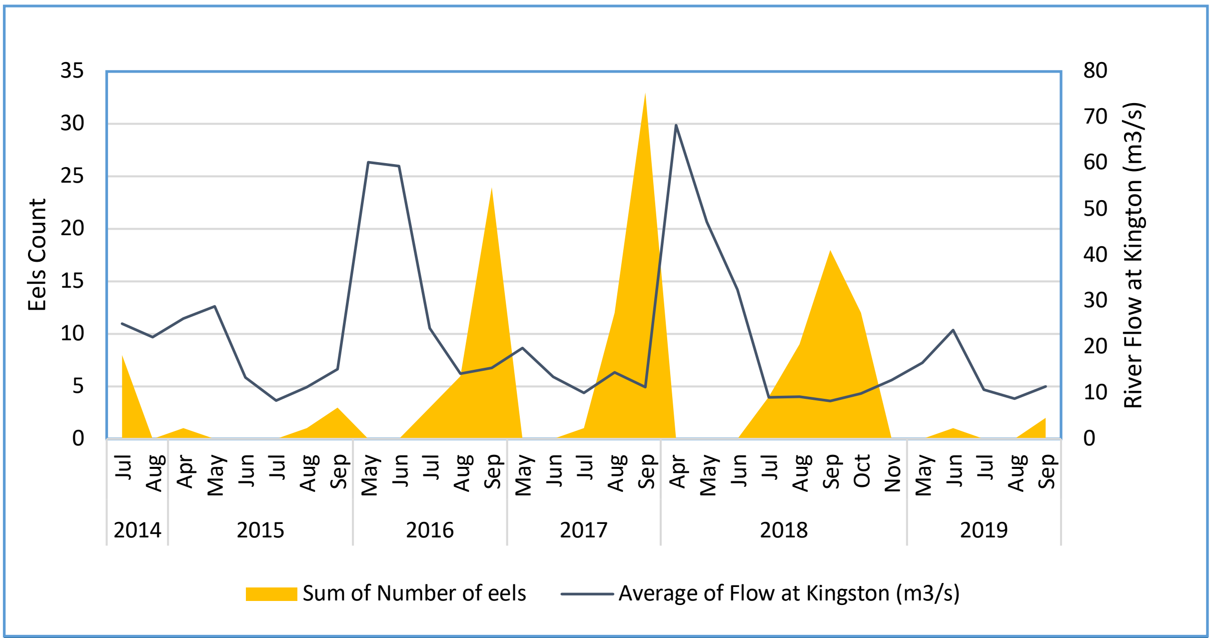
A.2.194 Daily mean river flow data was obtained from the EA`s Hydrology Data Explorer from the River Thames at Kingston to assess its correlation with eel migration and river flow. The eel migration was also assessed based on tidal levels in the Thames Tideway using daily tidal level data[46] for the Tower Pier.

A.2.195 Fifteen-minute level data was obtained from the Environment Agency for the water levels upstream and downstream of Teddington Weir from gauging station River Thames downstream of Teddington Lock. Daily flow data from the River Thames at Kingston gauging station (NRFA Ref. 39001) which is upstream of Teddington weir, was obtained from the National River Flow Archive (NRFA). The data assessed was for 28 years ranging from 1/1/1990 to 30/9/2023, excluding the years between 1998 and 2002 inclusive due to a lack of low flow periods during this time. Any days where data was absent for any 15 minutes were removed, and the data was also reduced to only show low flow days where the daily flows at Kingston were less than 1,000Ml/d. This provided a total of 1,944 dates for low flow assessment. Since the moon and sun governs the tidal cycle, the full moon and new moon dates were also included to determine the effects of the moon phases. This data was reviewed to determine the frequency and duration of the Teddington Weir being overtopped during low flow periods, the impact of the tide, and the height of overtopping the weir. Overtopping refers to where the tidal levels downstream of the weir exceed the water levels upstream resulting in a backflow over the weir. The scheme will not operate during overtopping events as recycled water from the outfall will be carried back to the intake.

A.2.196 Plate A.69 indicates that the number of eels caught in the trap at Teddington weir increases when the river flow falls below around $12m^3/s$. This might indicate that eels most likely use lower flow periods for upstream migration.

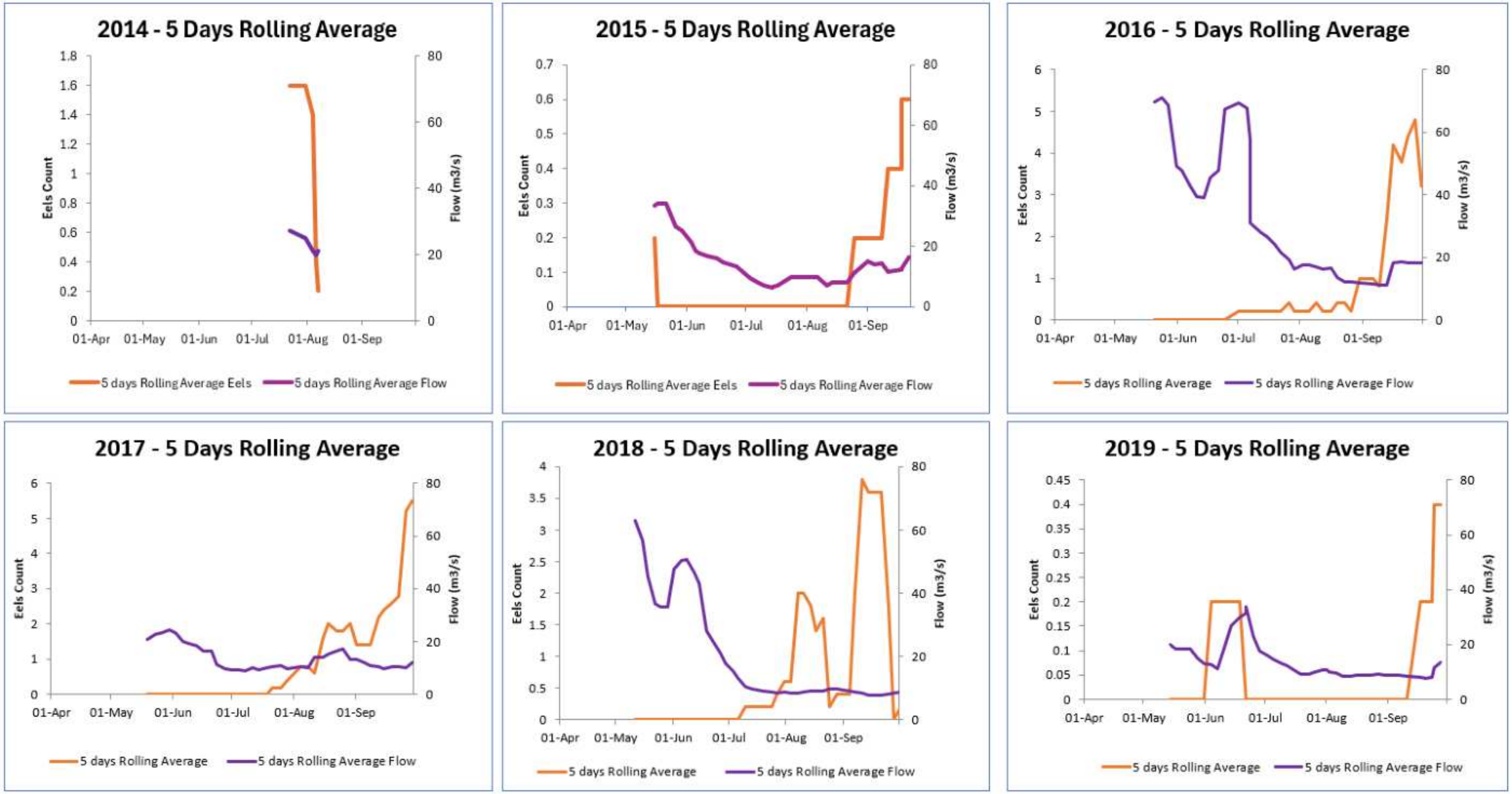
[46] The tidal level data was obtained from https://riverlevels.uk/thames-tideway-tower-pier-tidal.

Plate A.69 Number of eels at Teddington Weir and River flow at Kingston



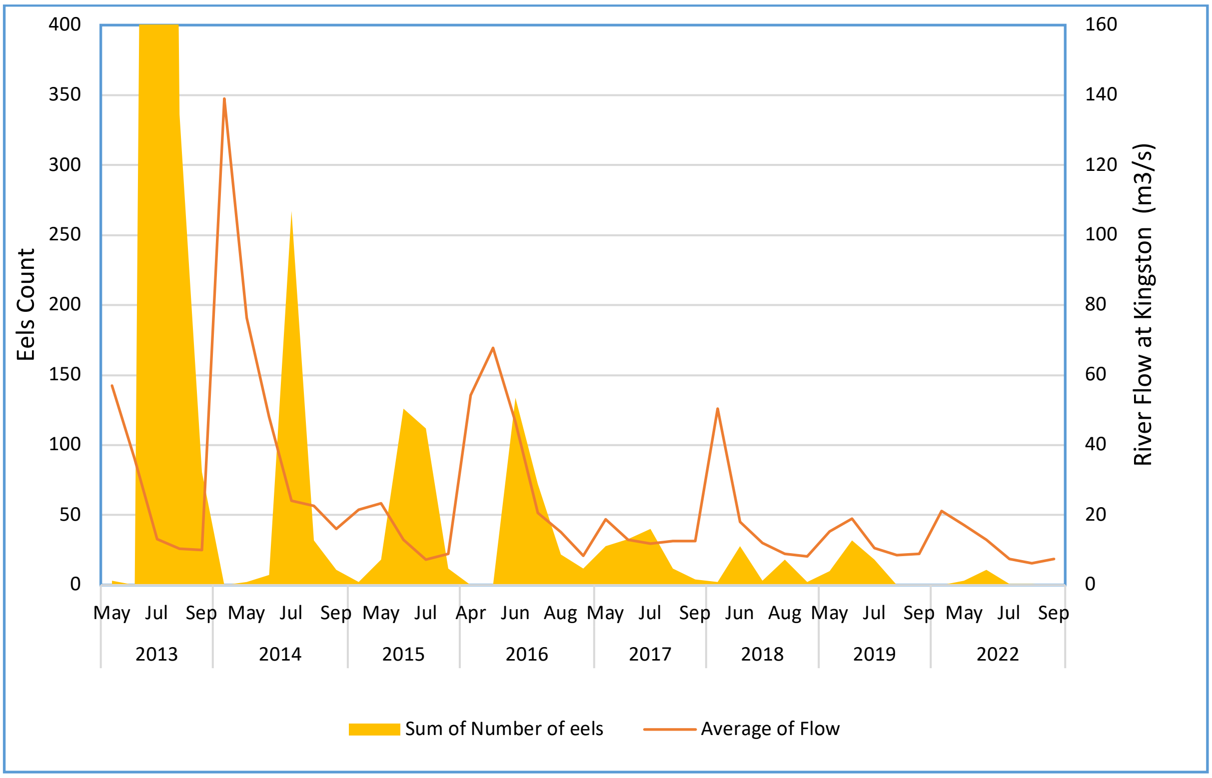
A.2.197 A 5-day rolling average calculation was made to understand eels' migration trends over time using the above-mentioned trap and flow data. The graphs were generated on a yearly basis in Plate A.70 which shows sum of eels count and river flow data over the eels migration period from 2014 to 2019.

Plate A.70 Days rolling average of eels at Teddington Trap and river flow data



A.2.198 Plate A.71 shows that eels were mainly seen in the Molesey Weir trap in July, August, and September when the flow fell below around 12 m^3/s. Although these data provide clues about upstream eel migration, it is thought that the data is insufficient to determine a definitive migration trend. The trap data at Molesey ranges from 2013 to 2019 and 2022. The data shows that the largest number of eels within the eels migration period (end of April to the end of September) was caught in 2013 with the number of 2440. This number decreased over the years of the data range (Plate A.71). It is seen that the number of eels in the Molesey Weir traps increases when the river flow decreases, or vice versa. This might indicate that eels most likely use lower flow periods for upstream migration.

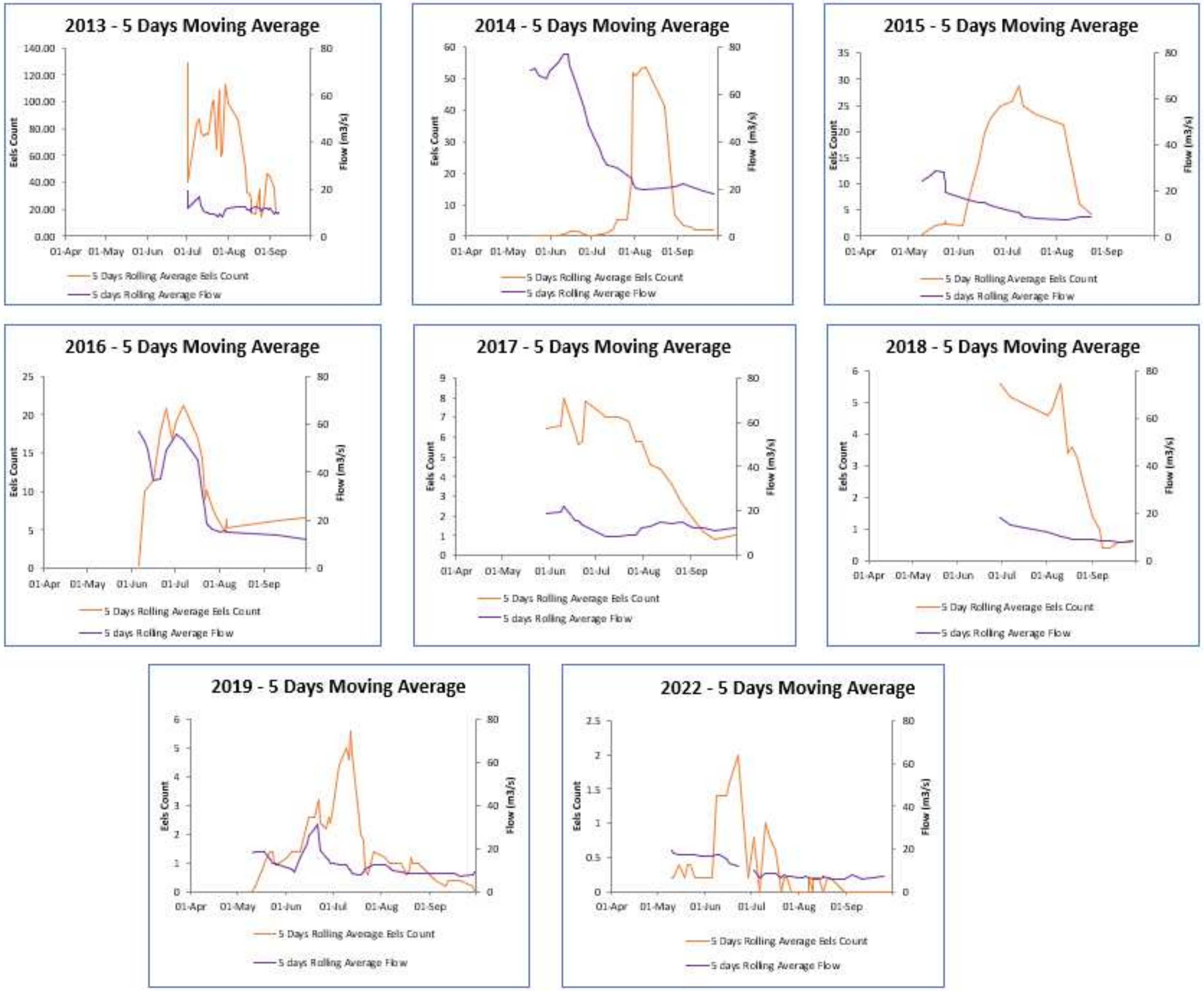
Plate A.71 The number of eels at Molesey Weir and River flow at Kingston



**The Y axis (Eel count) in the graph was limited to 400 to get a better visual representation.*

A.2.199 A 5-day rolling average of eels and river flow was calculated and given on a yearly basis in Plate A.72.

Plate A.72 Days rolling average of eels at Molesey and river flow data River Thames at Kingston

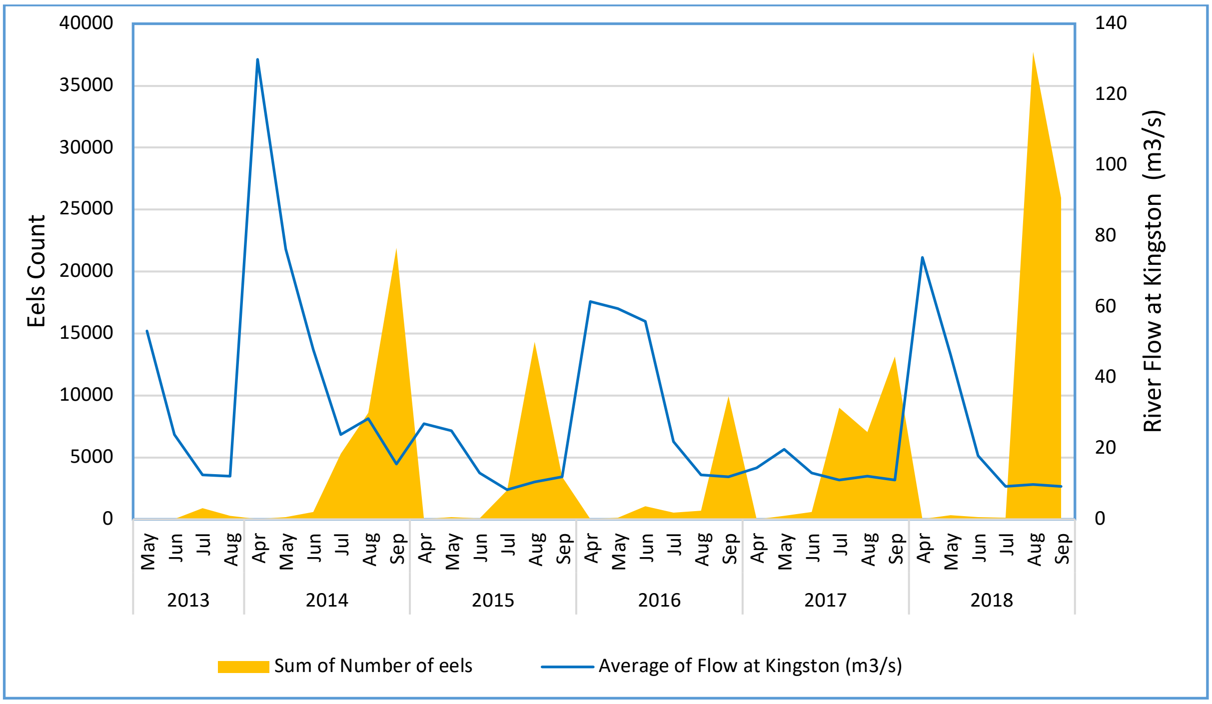


A.2.200 The graphs show that eels were seen in the Molesey trap throughout the traditional eel migration window starting in May and June (Plate A.72). It is noted that the number of eels caught has decreased noticeably over the years 2013 to 2022. The maximum number of eels was received in July and August.

A.2.201 In the Teddington trap data, it is observed that there is an increase in the number of eels caught in the trap when river flows fall below 10-12 m^3/s. There was a sharp increase in the rolling average of the number of eels in 2014 when the river flow fell below 20 m^3/s.

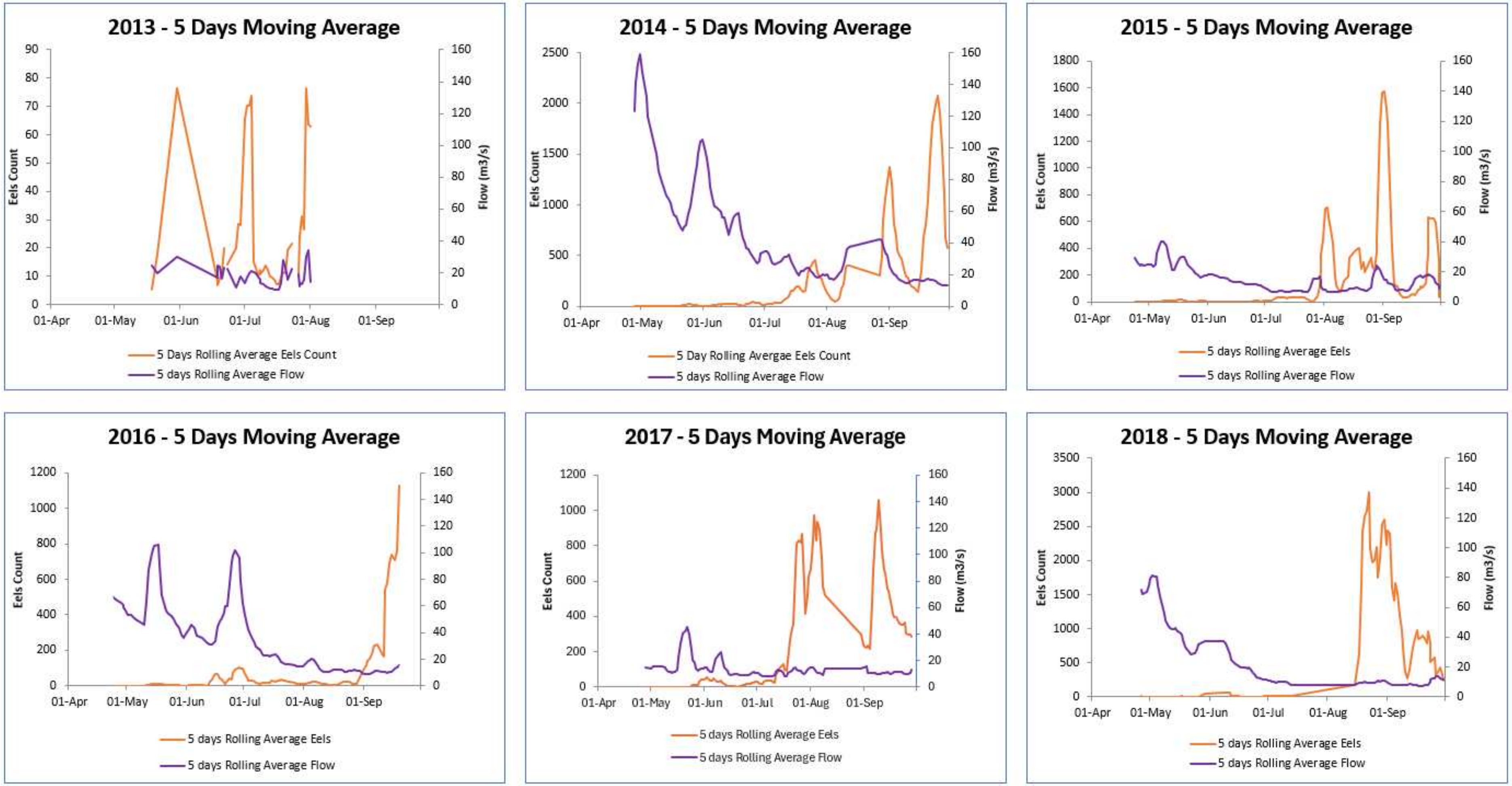
A.2.202 If we take a closer look at the River Brent trap data, it is seen that there are more eels caught than in the Teddington and Molesey Weir traps (Plate A.73). The maximum total number of eels were caught in 2018, 2014, and 2017, respectively. It is also seen in the graph that the highest number of eels counted in the trap was when the river flow was around between 15 m^3/s and 8 m^3/s.

Plate A.73 The number of eels at River Brent and River flow at Kingston



A.2.203 A 5-day rolling average calculation was made to understand eel migration trends over time using the River Brent trap and flow data. The graphs were generated on a yearly basis and given in Plate A.74.

Plate A.74 Days rolling average of eels at River Brent and river flow data River Thames at Kingston



A.2.204 Plate A.74 shows that an increase in eels was seen in the River Brent traps under lower river flow conditions, which is around $12m^3/s$, as seen in the Teddington and Molesey trap data. There is no clear correlation between the number of eels and river flow in 2013. It is seen that eels usually start their upstream migration in early June and reach peak numbers in July, August, and September in low flow conditions. However, migration occurred later in 2016 compared to other years, it is uncertain what the reason for the delay is, however, it is considered it may be linked to the 2015-2016 El Niño weather event affecting ocean currents. Based on the River Brent trap data, eel migration timing starts in the Thames in late June and early July and ends in September as the traditional eel migration window, with peaks in July and August.

A.2.205 The 5-day rolling average graphs for the Teddington and River Brent trap (Plate A.70 and Plate A.74) show that there is a distinct repeated peak in the eels' data. For Teddington eel trap data, two peaks occurred a month apart in 2018. For River Brent trap data, there were two peaks in 2014, three peaks in 2015, and two peaks in 2018 that occurred a month apart. It is also noted that the sub-peaks occurred a fortnight apart in 2017 and 2018. It is assumed that these regularities are driven by the tidal cycles.

A.2.206 The analysis has been expanded to correlate tidal levels and eel trap data to achieve a better understanding of eel migration using daily tidal level data[47] at Tower Pier in the Thames Tideway. Considering available eel trap data in River Brent, Teddington and Molesey Weir, River Brent eel trap data is considered appropriate to use for correlation analysis with tidal levels as there is more eel data, and it is located downstream of Teddington Weir, whereas Molesey is located upstream of Teddington Weir and is therefore not influenced by the Tides. The graphs were generated on a yearly basis to show details of the data (Plate A.75). According to 2014 data, the recorded tide level frequency was different compared to the other years, and there is no correlation between tide level and the number of eels. However, it is observed that there is a visible increase in the number of eels during the spring tide periods and the days immediately following this period in 2015 and 2016. When the key migration events (where the number of caught eels reaches its maximum) are evaluated according to the tidal periods, it can be said that these events occur only in spring tide periods in all years. It is noted that a large number of eels were caught during the neap tide period, especially in 2017 and 2018. In view of the above, it is assumed that upstream eel migration is partially, not completely, related to tide levels and that eels take advantage of spring tide periods for upstream migration.

A.2.207 According to the trap data, upstream migration of eels mostly happens in low-flow conditions. Therefore, the Teddington Weir overtopping events in low flow conditions, which is during periods when the water level of Teddington Weir downstream is higher than the water level of Teddington Weir upstream, have

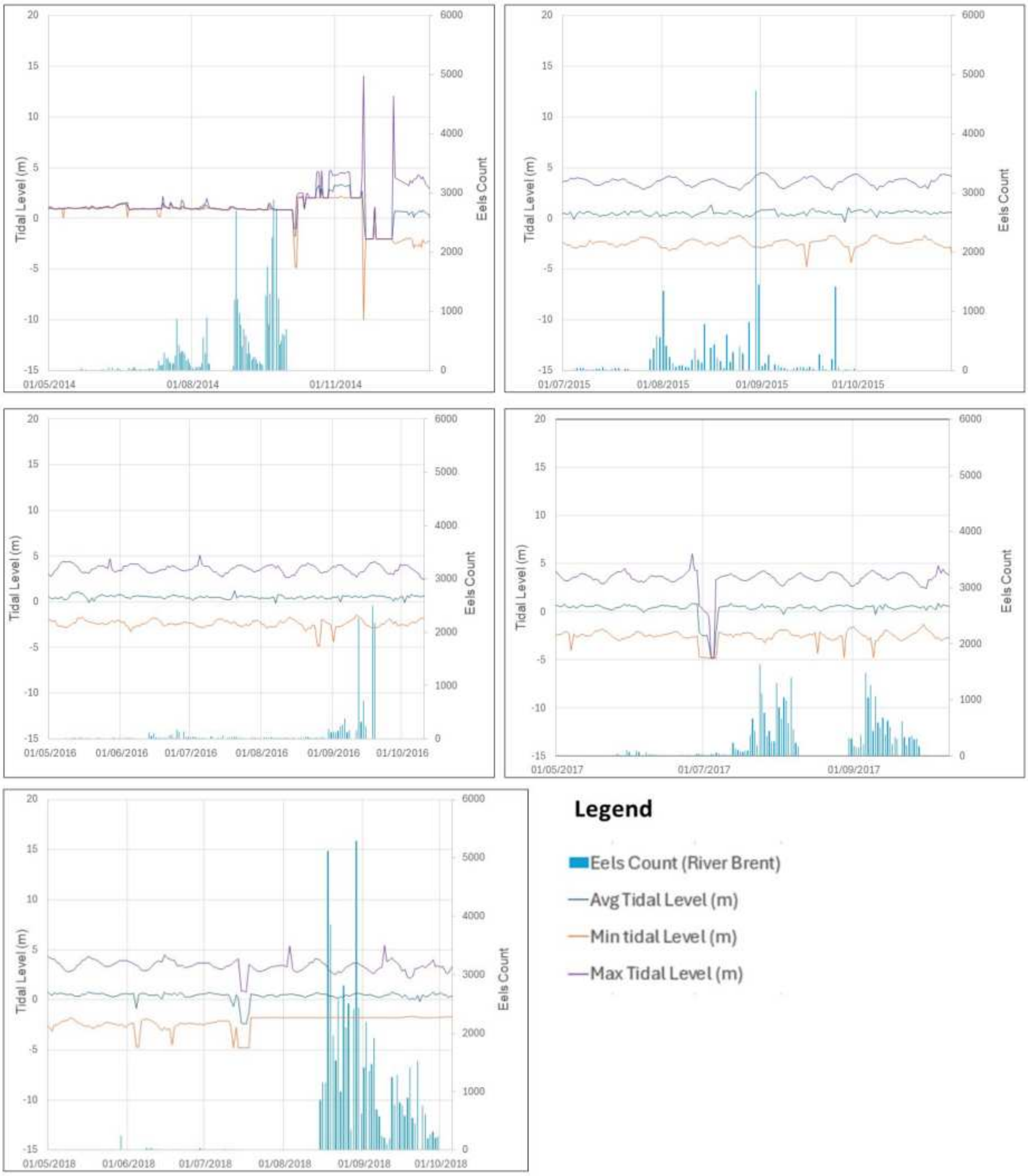
[47] The tidal level data was obtained from https://riverlevels.uk/thames-tideway-tower-pier-tidal.

also been assessed to understand the impacts of the Project on eel migration. When Teddington Weir overtopped, the scheme, if active, would turn off since the discharge from the outfall would be taken back to the intake. The details of the overtopping assessment are given below.

A.2.208 In total, there are 1,944 low-flow dates with complete level data in 24 hours between 1/1/1990 and 30/09/2023 (excluding dates between 1/1/1998 and 31/12/2002 which do not contain consistent low flow periods required for assessment). During these low-flow dates, Teddington Weir was overtopped on 473 separate occasions across 308 dates (15.8% of the low-flow dates). One hundred and forty-three dates had a single event where the weir overtopped (7.4% of the low-flow dates), while 165 dates had two events during the day where the weir was overtopped (8.5% of low-flow dates).

A.2.209 Each weir topping event lasted for an average of 30 minutes with an average maximum height of 0.08m above the upstream weir level. The maximum length of time for an event overtopping the weir was 120 minutes, with a maximum height of 1.07m above the upstream weir level on 24th July 1994. This was preceded by another overtopping event on the same date for 105 minutes with a maximum overtopping height of 1.10m, which was not exceeded in any other event. The minimum length of time for an overtopping event was a single occurrence, which occurred frequently for 185 events out of the total 473 events (39.1% of all overtopping events).

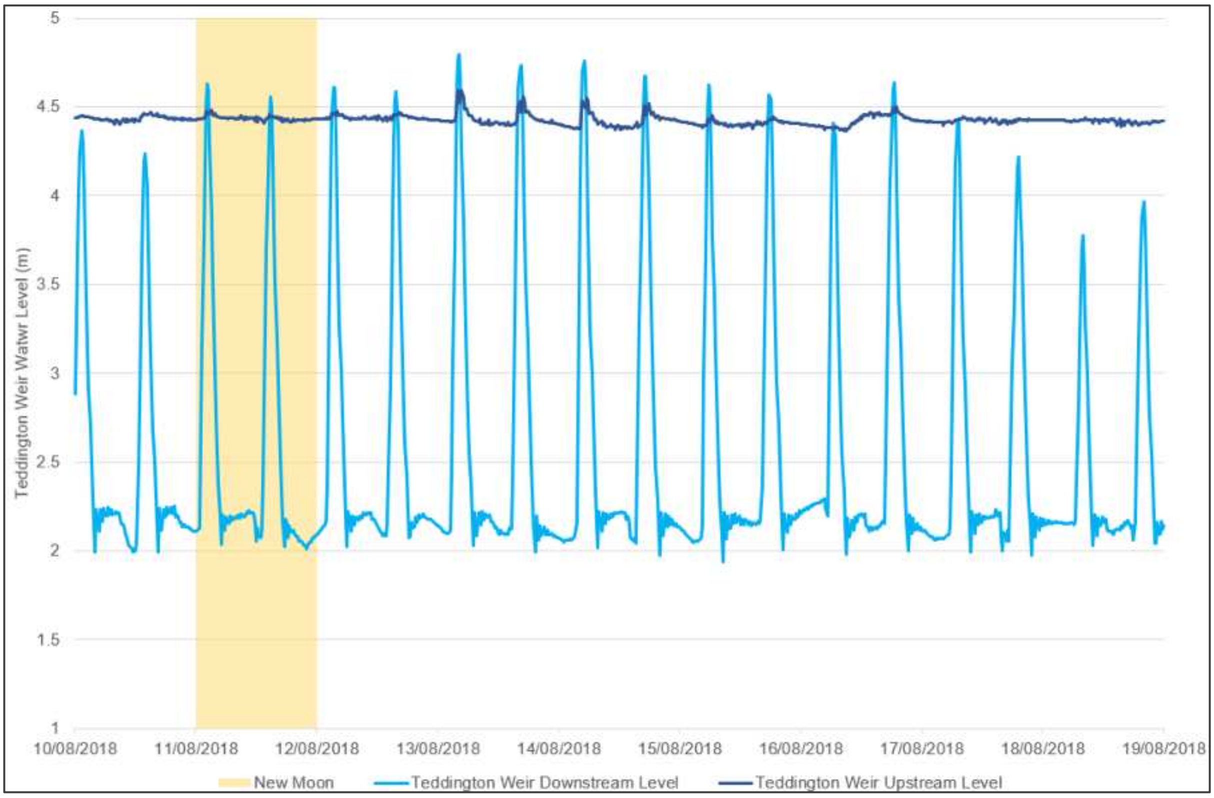
Plate A.75 Comparison of the number of eels in River Brent trap and tidal level from River Tideway at Tower Pier (Note: Negative values in the graph indicates that the water level is below the reference point, also known as the chart datum or zero tide level)



A.2.210 The 473 overtopping events often occur in a period on the same or consecutive dates. If each event is combined into sequential periods on the same date or consecutive dates, the events form 144 periods. On average, each period consists of three overtopping events, with 52 overtopping events not reoccurring on preceding or subsequent days. The longest period covers 13 overtopping events between 11th August 2018 and 17th August 2018 (Plate

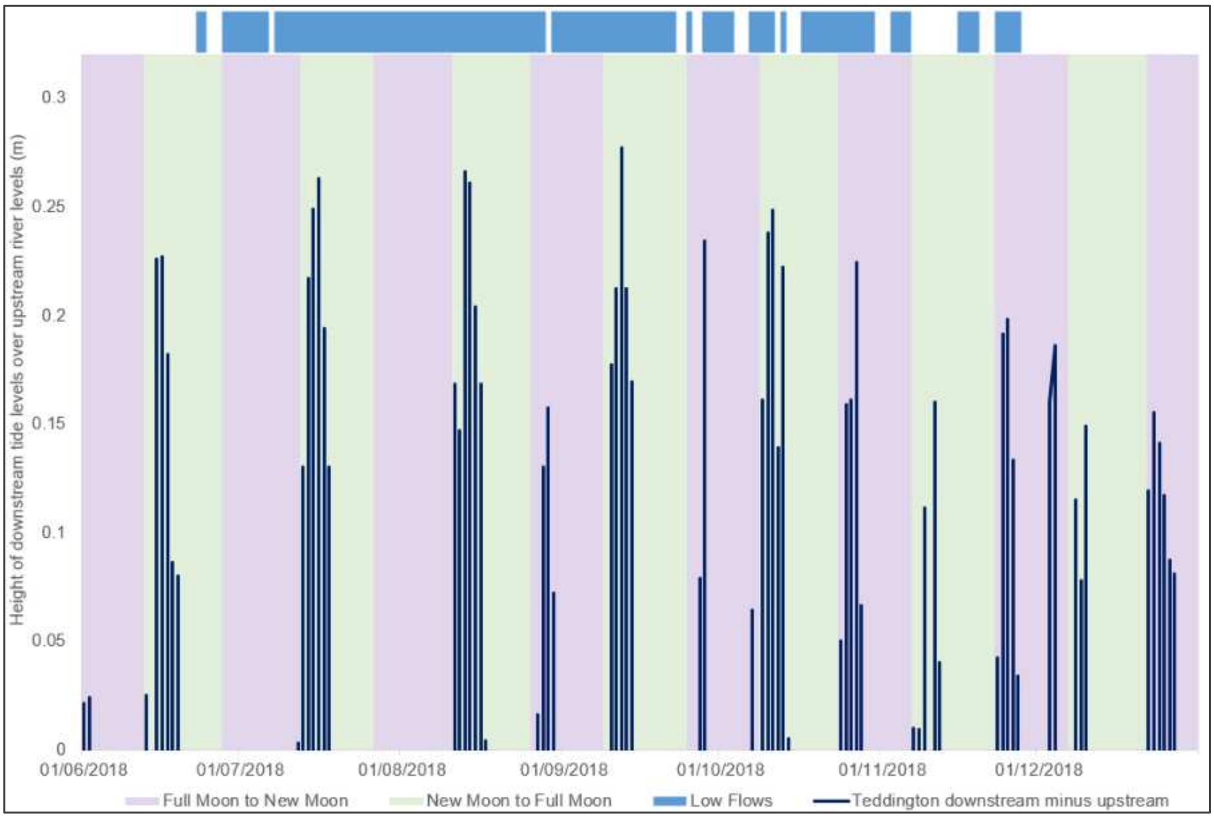
A.76). It is assumed that the reason for the ‘skid’ between the highest tide level and the moon phases in Plate A.76 is because of the Earth's rotation: as the Earth spins, the tidal bulges-caused by the moon's gravity and centrifugal force-lag slightly behind the moon's position, meaning high tide usually occurs a few hours after the moon is at its peak, resulting in a slight time difference between the lunar phase and the highest tide at a given location.

Plate A.76 Teddington Weir overtopping during low flows between 10th August and 19th August 2018 using gauged flow data from the River Thames downstream of Teddington Lock and the River thames upstream of Teddington Lock



A.2.211 Due to the volume of data assessed, a representative period of low flows was identified between June 2018 and December 2018, when the weir was overtopped. This is shown in Plate A.77 below. As shown, the periods of Teddington Weir being overtopped tend to coincide with the moon phase around the times of the full moon and new moon (spring tides). However, there is some variability with the exact timing and period of the overtopping of the weir around these dates. It does not appear that low flows significantly increase or reduce the level of overtopping.

Plate A.77 Teddington Weir overtopping during low flows between June and December 2018



A.2.212 Overall, it can be expected that overtopping of Teddington Weir will occur during the low flow periods, depending on the natural moon cycle.

A.2.213 The Teddington Weir overtopping events in low flow conditions and eel trap data in River Brent (from 2013 to 2018) with predicted TDRA operational period were analysed to understand whether the weir overtopping might drive eel movement past the weir (Plate A.77). The dates when eels were found (at least one) in the River Brent eels trap were extracted, and these dates were compared annually with the dates of the overtopping events that occurred (Table A.30). In 2013, the overtopping events happened on 17 of the 46 days when eels were recorded in the trap, which corresponds to 36% of the total. The average number of eels caught across all sampling days was 26.9, the mean for days with only overtopping occurrences was 36.3, and the mean for the days without overtopping events was 21.4. It is seen that there is an increase in the number of eels in dates of overtopping events. No overtopping events occurred in 2014. In 2015, overtopping events accounted for 52% of the days on which eels were documented. The average number of eels caught across all sampling days, including all sampling range, were 144, 182 and 103, respectively. The number of eels also clearly increased in the overtopping event dates in 2015. In 2016, overtopping events accounted for 23% of the days on which eels were documented. It is observed that the average number of eels caught in 2016 almost doubled on the dates when overtopping events were observed, with 213 eels trapped. The average number of eels in the trap was 90, excluding days of overtopping events. The overtopping events accounted for 58% and 54% of the days on which eels were recorded in 2017 and 2018, respectively. There was a clear increase in the average number of eels when the weir overtopped in 2017 and 2018. (Table A.30).

Table A.30 Comparison of average number of eels with and without weir overtopping events

Years	The overtopping events occurrence within the eels trap data range (%)	Average eels count in River Brent		
		All sampling range	Dates when only overtopping events occurred	Days without overtopping occurrence
2013	36	26.9	36.3	21.4
2014	0	-	-	-
2015	52	144	182	103
2016	23	118	213	90
2017	58	272	322	203
2018	54	595	925	197

A.2.214 The overtopping events were also assessed against the projected Project operational period, which is once every two to three years. Based on this, the Project would not be operational in 2013, 2014, and 2016 within the period of eel trap data in River Brent.

A.2.215 Based on flow conditions in the River Thames in 2015, the Project is modelled to be operational for 101 days in a 183-calendar day range from April to September (inclusive), which is around 55% of the time. Overtopping events occurred on 14 days out of the 101 days (14%) that the Project was operational, and the Project would be non-operational on days where Teddington Weir overtops. The maximum number of eels was recorded on 30th August 2015 and 31st August 2015, with 4723 and 1452, respectively, when the overtopping event occurred, where the tide levels were 4.18m and 4.42m (Plate A.78). In 2015, the scheme would have been operational during 47% of the key eel migration period (not including overtopping days) (Table A.31).

A.2.216 In 2017, the Project would be operational for 93 days in a 183-calendar day range from April to September (inclusive), which is around 50% of the time. Overtopping events occurred on 22 days out of the 93 days (24%) that the Project was operational, and the Project would be off on these days. The maximum number of eels was recorded on 24th July (1642), 08th September (1268), 25th July (1119), 10th September (1066) and 07th September (1043), respectively, when the overtopping event occurred. The recorded tide levels ranged from 3.99m to 4.26m in these days (Table A.31). In 2017, the scheme would have been operational during 38% of the key eel migration period (not including overtopping days) (Table A.31).

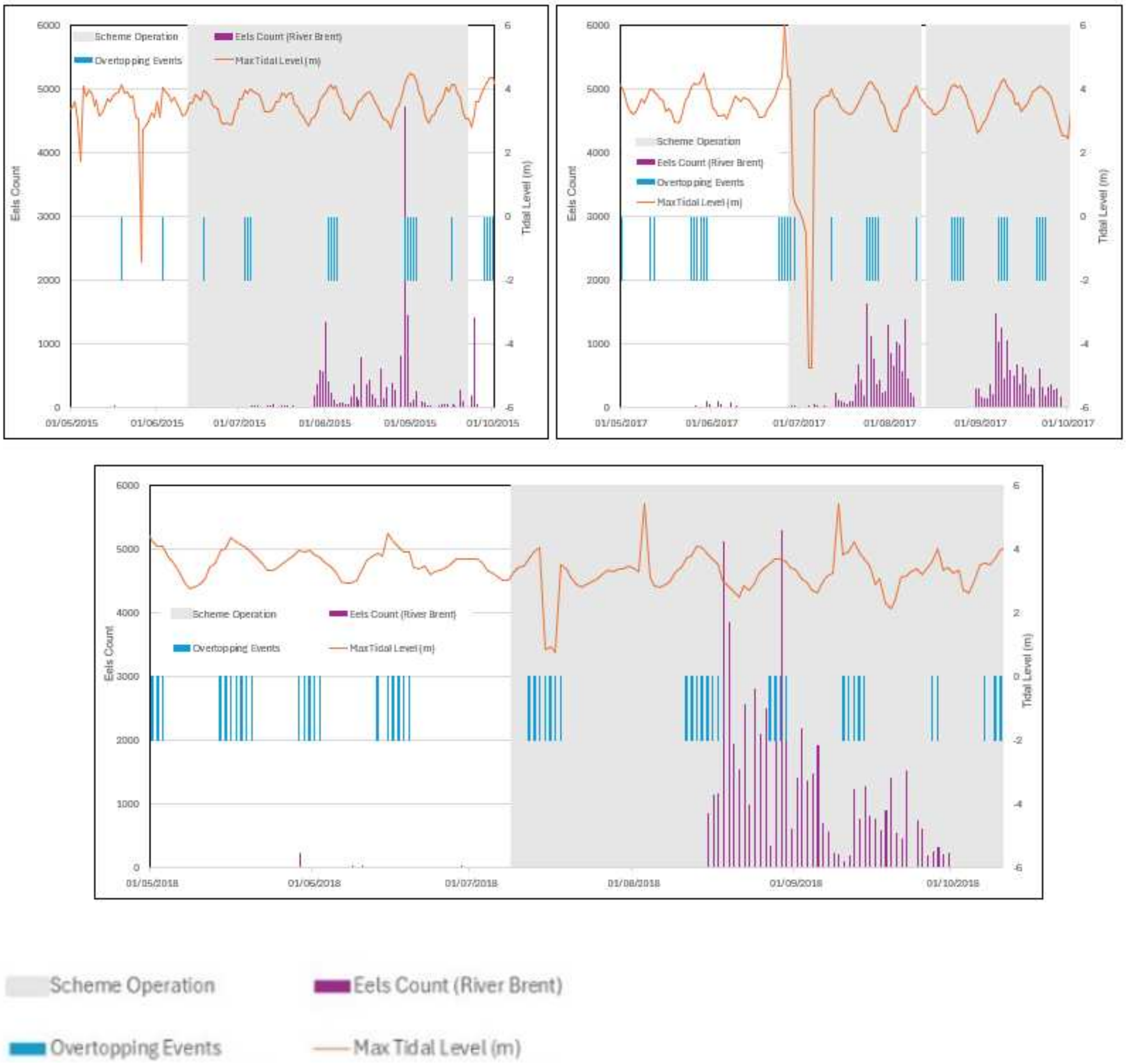
A.2.217 In 2018, the Project would be operational for 84 days in a 183-calendar day range from April to September (inclusive), which is around 46% of the time. Overtopping events occurred on 25 days out of the 84 days (30%) that the Project was operational, and the Project would be off on these days. Across seven of these overtopping dates (August: 16th,17th,28th, 19th, 30th and September: 12th, 14th) 13,933 eels were recorded in the Brent eel traps, comprising 21.6% of eels recorded in 2018The recorded tide levels ranged from 3.43m to 4.20m in these days (Plate A.78). In 2018, the scheme would have been operational during 32% of the key eel migration period (not including overtopping days identified to account for peak numbers of eel movement) (Table A.31).

Table A.31 Summary table for percentage days of scheme operation, with and without overtopping days (Note: Percentages generated from April to September (inclusive) periods for each year.)

Years	Days scheme would be operational (%)	Days of overtopping on operational days (%)	Days of scheme operational minus the overtopping days (%)
2015	55	14	47
2017	50	24	38
2018	46	30	32

A.2.218 Considering the eel trap data range (2013-2018), it is noted that when factoring in no operation on overtopping days that a 6-year average of scheme operational days overlap with the eel migration period of April to September is approximately 20%.

Plate A.78 Comparison with project operation and overtopping dates with the River Brent eels trap data and tidal level Thames Tideway at Tower Pier (Note: Blue bars only indicate dates of overtopping events, not related to values of vertical axes)



Eel Migration within the Thames

A.2.219 The eels trap data shows that eels predominantly move upstream during low flows. Based on the available data, the elvers' upstream migration past Teddington Weir occurs in late June and early July and ends in September, with peak migration occurring in July, August and September. Data from the River Brent in 2015 included eel trapping data collected up until the end of November and recorded elvers in both October and November. However, only 1.35% of elvers captured were recorded in both October and November. Of 1.35%, 1.03% were recorded in the first two weeks of October (October 1st to 14th), when conditions will still be similar to those recorded in September, with the remaining 0.32% recorded after these dates. This assessment considers April to September to be the main elver migration period, as is widely reported. However, elver movement can occur outside of this period. As mentioned, the upstream eel migration is not uniform and may be influenced by a variety of environmental and behavioural factors, such as elver feeding and sheltering within the estuary prior to entering freshwater habitats.

A.2.220 The Project will most likely operate during low or moderate-low flow periods only in order to maintain essential water supply to Thames Water customers during times of water stress. When in operation, the modelling undertaken to date has indicated that the Project would typically be used in August through to November, which partly matches eels 'upstream migration period.

A.2.221 The eel trap data and tidal level correlation assessment indicate that there is no direct correlation between tidal level and eel upstream migration. It is observed that there is a visible increase in the number of eels during the spring tide periods and the days immediately following this period (Plate A.78). Therefore, it is assumed that upstream eel migration is partially related to tide levels and that eels take advantage of spring tides for upstream migration. When the key migration events (where the number of caught eels reaches its maximum) are evaluated according to the tidal periods, it can be said that these events occur only in spring tide periods in all years. It is also noted that a large number of eels were caught during the neap tide period, especially in 2017 and 2018. This reinforces that there is no direct correlation between eel migration and tidal levels. Due to the length of time it will take juvenile eel to pass through the estuary, there is not a specific migration peak on a specific tide, as evidenced in the eel trap data. However, based on the regularity of the Brent trap data, there does seem to be a tidal cycle in juvenile eel migration where large numbers of eel were recorded during spring tides. It is currently hypothesised that juvenile eel are travelling up the estuarine Thames via STST and then utilising spring tides to bypass the tidal barriers in large numbers, noting the findings of Benson *et al.* (2021)[48] and Boardman *et al.* (2024)[49].

A.2.222 The assessments show that there is a clear increase in the average number of eels on the dates Teddington Weir overtopped (Table A.30). However, it is noted that this assessment is made comparing Teddington overtopping events to eel trap data on the Brent as there is not enough data available from the Teddington trap to show eel clearance trends at Teddington Weir. Therefore, this data indicates that on spring tides, eel are attempting to clear the tidal barriers. Considering the notable rise in the number of eels during the dates of weir overtopping and the increase in the number of eels at high tidal levels, it is assumed that the weir overtopping affects the movements of eels, and this most likely drives the eels' movement to pass Teddington Weir, noting that the eels data obtained from River Brent eels trap, which is located downstream of Teddington Weir.

[48] Benson T, de Bie J, Gaskell J, Vezza P, Kerr JR, Lumbroso D, Owen MR, Paul S. Kemp PS (2021) Agent-based modelling of juvenile eel migration via selective tidal stream transport, Ecological Modelling 443
[49] Boardman, R.M., Pinder, A.C., Piper, A.T. , Gutmann Roberts C, Wright RM and & Britton JR (2024) Variability in the duration and timing of the estuarine to freshwater transition of critically endangered European eel Anguilla anguilla. Aquatic Science 86, 18

A.2.223 As evidenced by Benson *et al.* (2021) [50], clearance of the Thames estuary by European eel elvers will take at least two weeks. The eel trap data highlights that eels do not arrive at the tidal barriers in a single peak. Rather, they arrive in 'waves' that form multiple peaks across the migration season, supporting the theory of expedient migration through the utilisation of STST. The data further indicates the easiest mechanism for mass clearance of the tidal barriers on the Thames is utilising spring tides on the full or new moons, which regularly coincide with Teddington Weir overtopping.

A.2.224 During these overtopping events the scheme would be off to prevent abstraction at the intake of recycled water from the outfall. As a result the potential impact of the Project on eel migration would be reduced as the Project will not be operational during these identified key migration events. Furthermore, factoring in non-operational days on overtopping events with the operational frequency across a 6-year average for the period of 2013-2018, the timing of the overlap with the eel migration period of April to September is reduced to 20%.

Salmonids

A.2.225 The migratory behaviours of Atlantic salmon and sea (anadromous)/ brown (resident or potodromous) trout are influenced by a large variety of variables within larger catchments (owing to distance from spawning ground and hydromorphologies), including fish size, behaviour, life-history, strategy, and movement response to flow-related cues[28]. It is generally accepted that upstream salmonid migration is positively influenced by increasing flow (discharge rate) or, specifically, by hydraulic cues, including velocity, depth, turbulence, shear, and flow-associated cues. Salmonid migration is also influenced by noise, turbidity, temperature, and chemical characteristics (i.e., olfaction). Spawning and egg incubation occur within river gravels between November and February for diadromous salmonids, while resident brown trout spawn later, often between November and February, however may spill over into March[51]. The peak of spawning activity and redd development can vary geographically within the UK, and also by up to a few weeks from year to year, dependent on river flow and temperature. During reproduction, females dig a hole in the gravel into which they lay eggs. Upon deposition and fertilisation of the eggs, the eggs are covered with gravel and the nest, or "redd", is completed. The 'alevins' (life stage which is free-swming but retaining the yolk as a nutrient source) of salmonids may undergo a period of imprinting shortly after hatching. During this stage the chemical nature of the natal watercourse is learned using olfactory senses, which allow individuals to accurately home to their natal stream during return spawning migrations. In preparation for life at sea juvenile salmonids undergo "smolification" (a significant change in

[50] Benson T, de Bie J, Gaskell J, Vezza P, Kerr JR, Lumbroso D, Owen MR, Paul S. Kemp PS (2021) Agent-based modelling of juvenile eel migration via selective tidal stream transport, Ecological Modelling 443
[51] García-Vega, A., Fuentes-Pérez, J.F., Leunda Urretabizkaia, P.M., Ganuza, J.A., and Sanz-Ronda, F.J. (2022). Upstream migration of anadromous and potamodromous brown trout: patterns and triggers in a 25-year overview. *Hydrobiologia*. 849, pp. 197-213.

morphology, physiology, and behaviour) triggered through exposure to "releasing" factors or cues, including changes in light, turbidity, temperature, and water discharge[52]. Following this process smolts migrate downstream out to sea where they feed and mature. The timing of adult salmonids returning on their spawning migration may vary based on a number of factors including food availability and environmental variables, however, adult returning salmonids have been recorded in the Thames as early as July. Adult salmonids return to their river of origin preferring to spawn in tributaries in gravel beds where they can dig their redds, typically in well oxygenated faster flowing water such as riffles. Barriers, such as weirs, impede migration to these spawing grounds. Post-spawning, the majority of spent (or spawned) adults, known as "kelt", are weakened as they have not eaten since their arrival in freshwater, have laid eggs or fought over access to mates, and therefore the majority die before going back out to sea. Despite salmonids having a high fidelity to their natal river, only a few display iteroparity, returning to the sea to repeat spawn the following year. The majority of kelts overwinter, resting in pools before descending in spring. However, if access to habitat is limited, they may leave rivers directly after spawning.

A.2.226 Resident brown trout are widespread within the Thames catchment, having been recorded at 337 out of 1395 freshwater and TRaC monitoring sites since 1978 throughout the catchment. However, it is not possible to distinguish between freshwater resident brown and anadromous sea trout within the EA's freshwater or TRaC monitoring dataset (since the data set does not differentiate the two). Therefore, the proportion of the recorded brown trout exhibiting the anadromous life cycle is not known. That said, there is a network of fish passes suited to aiding the migration of sea trout to spawning habitat in the catchment, including a fish pass at Teddington Weir, with reports of individuals having been captured in headwater grounds upstream of the investigated reaches. In contrast, Atlantic salmon are relatively sparse within the catchment, having only been recorded at seven monitoring sites, with a total of 18 individuals having been captured since 1992. Three sites which recorded the species are located on the River Kennet near Reading, with the remaining sites located on the River Thames at Marlow, Maidenhead and Windsor.

Annual Catch Salmonid Fish Trap Data (Molesey Weir)

A.2.227 The EA has supplied annual catch data for both Atlantic salmon and sea trout at Molesey Weir fish trap from 1970 to 2016. This indicates the trends of the salmonid upstream spawning migration within the Thames catchment and is displayed in Plate A.79 and Plate A.80 below. It can be seen that trends in the number of fish caught at Molesey Weir fish trap fluctuate year on year. However, after a peak of 338 Atlantic salmon caught in 1993, the catch return has diminished, with catches after 2005 returning no more than a maximum of 15 fish recorded in 2012. Sea trout catch returns have a lower peak than salmon at 60 fish caught in 2009. However, the number of catches generally

[52] McCormick, S.D., Hansen, L.P., Quinn, T.P., and Saunders, R.L. (1998). Movement, migration, and smolting of Atlantic salmon (*Salmo salar*). Can. J. Fish. Aquat. Sci. 55(Suppl. 1), pp. 77-92.

trended upward until 2013, where a decrease can be seen with the 5-year rolling average falling below that recorded in 1994. Unfortunately, no data after 2016 is available for salmonids from Molesey fish trap; therefore, more recent trends in salmonid migration cannot be assessed.

Plate A.79 Annual Molesey Weir fish trap data for Atlantic salmon from 1970 to 2016

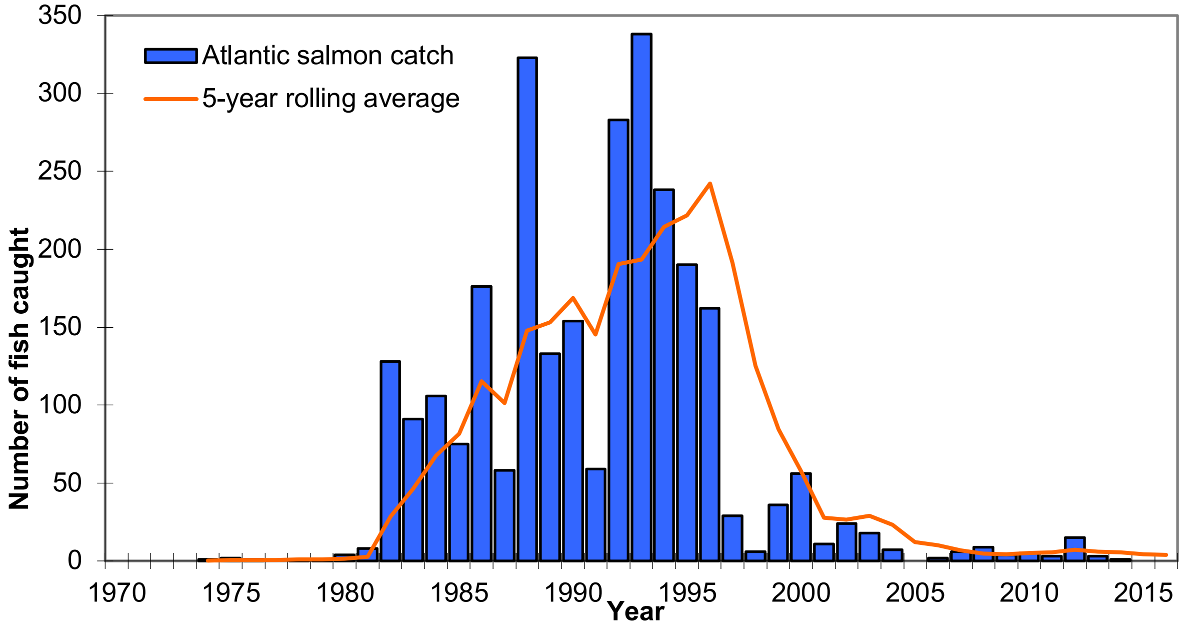
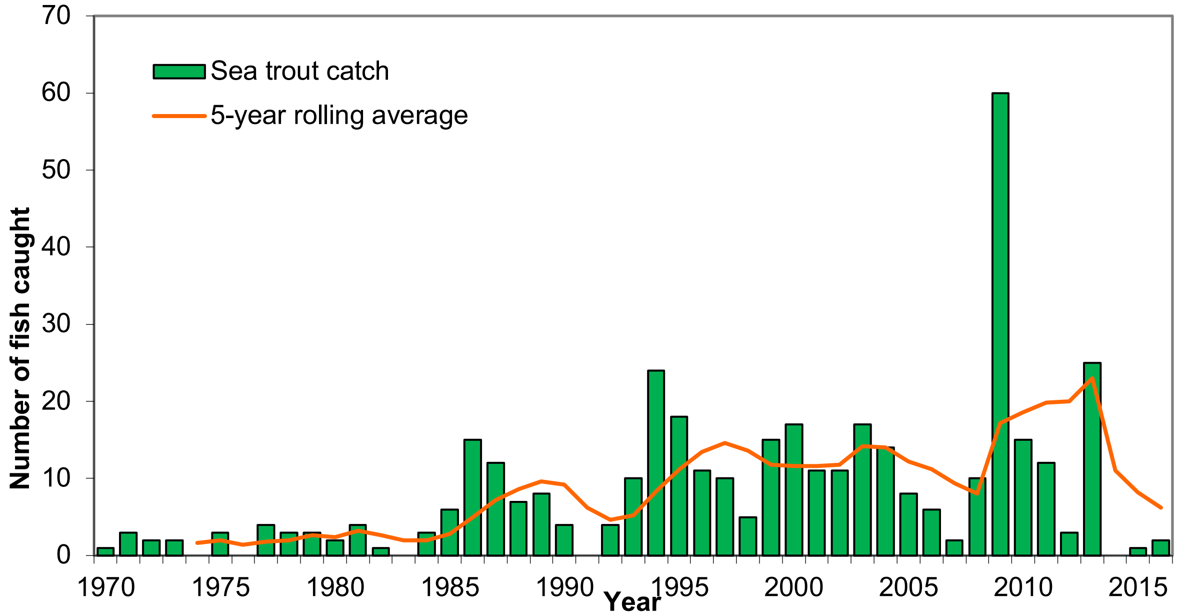


Plate A.80 Annual Molesey Weir fish trap data for sea trout from 1970 to 2016



European River Lamprey

A.2.228 River lamprey migrate upstream into rivers during the night from their coastal feeding grounds in autumn (sexually undeveloped) and spring (in spawning condition). Spawning starts when the water temperature reaches 10 to 11°C (typically March and April) in large depressions called 'nests', where they have cleared areas within cobbles/gravel/pebbles substrate. Following the egg incubation and hatching period (15 – 30 days post spawning), the young move to nursery habitat within areas of sandy silt where they live in burrows for several years (ammocoete phase) before metamorphosing to the adult form (July to September) and migrating downstream to the estuary[53].

A.2.229 Within the EA's freshwater dataset for the River Thames catchment *Lampetra sp*. are sparse within the catchment and have only been recorded at 17 freshwater monitoring sites, with a total of 141 individuals captured between 1993 and 2022. The majority of recorded occurrences are located at sites within or along tributaries of the River Medway. Several sites with records are located on tributaries of the River Mole, which flows into the River Thames, such as the River Ember near Hampton Court. However, it should be noted that *Lampetra sp*., such as river and brook lamprey, are not distinguished within the EA dataset, meaning the proportion of records ascribed to migratory river lamprey as opposed to resident brook lamprey is not known.

Sea Lamprey

A.2.230 Sea lamprey spend their adult life at sea and migrate into freshwater to spawn on clean gravels, with similar spawning habitat requirements to Atlantic salmon[54]. Adults migrate in spring, April - May, and can migrate long distances upstream, provided there are no barriers to movement (for example, weirs). After hatching, emergent individuals drift downstream and burrow into areas of soft silt and sand. Known as 'ammocoetes' (juvenile lamprey), they remain in this habitat for approximately five years, after which they metamorphose into adult lamprey and migrate to the sea between July and September. Olfaction may play an important role during several stages of the lamprey life history, and studies suggest that spawning migrations are initiated by a range of environmental cues, including flow, temperature, tidal and diel phases, as well as chemical olfactory cues. However, unlike the 'alevins' of salmonid species, which undergo a period of natal stream imprinting shortly after hatching, lampreys use odours to identify suitable spawning habitat, search for mates, and reduce predation risk through their sense of smell (olfaction)[55]. Larvae excrete lamprey-specific bile acids[56] into the water to create a detectable

[53] Maitland, P.S. (2003). Ecology of the River, Brook and Sea Lamprey. Conserving Natura 2000 Rivers Ecology Series No. 5. English Nature, Peterborough.
[54] Maitland, P.S. (2003). Ecology of the River, Brook and Sea Lamprey. Conserving Natura 2000 Rivers Ecology Series No. 5. English Nature, Peterborough.
[55] Wagner, C.M., Stroud, E.M., Meckley, T.D., and Kraft, C. (2011). A deathly odour suggests a new sustainable tool for controlling a costly invasive species. Can. J. Aquat. Sci. 68, pp. 1157-1160.
[56] Haslewood, G.A.D., Tökés, L. (1969). Comparative studies of bile salts. Bile salts of the lamprey Petromyzon marinus L. Biochem J. 149, p. 179.

concentration[57] to elicit strong an olfactory response to influence the behaviour of migratory lamprey in laboratory set-ups. Responses under real-world field conditions have not been investigated[58]. Olfactory responses may be influenced by discharges interfering with chemical cue detection.

A.2.231 Within the Thames catchment, sea lamprey are recorded infrequently, with EA freshwater survey data records indicating Petromyzontidae records from 11 freshwater monitoring sites captured by electric-fishing, with a total of 50 individuals captured within the dataset. The majority of records are at sites within or along tributaries of the River Medway and River Lee, with smaller numbers located in tributaries of the River Loddon and the River Mole. However, it should be noted that Petromyzontidae could be brook or river lamprey (*Lampetra sp.*). At the same sites *Lampetra sp.* have been recorded in other years therefore confidence in these records representing sea lamprey is low.

Twaite shad

A.2.232 In April and May, adult twaite shad gather in estuaries before moving upstream to spawn from mid-May to mid-July, with males swimming upstream in advance of females joining them[59]. This process appears to be triggered by temperature when the water reaches 10-14°C[60]. However, spawning runs are also influenced by factors including estuarine tides and river flows, with adults often moving into estuaries on spring tides and higher water discharge levels[59]. The role of olfaction in twaite and allis shad migration has not been subject to extensive research. Spawning of Twaite shad takes place over clean stones and gravel, within flowing water, into which the eggs sink. Eggs hatch after about four to six days, after which young fish drop downstream in the current to areas within the upper estuary to feed and grow. Twaite shad may spawn in, or just above, the tidal reaches of rivers. However, some stocks spawn further upstream. They may spawn multiple times throughout their lives[59], with evidence for the location of a nursery ground in the Thames inner estuary above Southend[61].

A.2.233 There are no records of twaite shad within the EA freshwater monitoring database for the River Thames. However, it is understood that a single twaite shad was captured in the Middle Thames Tideway at Blackfriars in 2019 as part of a fish rescue[62]. Historically, the species were present throughout the Thames

[57] Fine, J.M., Sorensen, P.W. (2010). Production and fate of the sea lamprey migratory pheromone. Fish. Physiol. Biochem. 36, pp. 1013 – 1020.
[58] Sorensen, P.W., Fine, J.M., Dvornikovs, V., Jeffrey, C.S., Shao, F., Wang, J. et al. (2005). Mixture of new sulphated steroids functions as a migratory pheromone in the sea lamprey. Nat. Chem. Biol. 1, pp. 324 – 328.
[59] Maitland, P.S., and Hatton-Ellis, T.W. (2003). Ecology of the Allis and Twaite Shad. Conserving Natura 2000. Rivers Ecology Series No. 3. English Nature, Peterborough.
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Tideway[63], and following water quality improvements in the 1980s, several size classes are indeed evident in the Tideway, below West Thurrock[64]. While eDNA monitoring surveys in 2022 did not detect the presence of any twaite shad eDNA within the Thames Tideway, eDNA monitoring surveys completed within the freshwater River Thames in the summer of 2023 noted a detection for the genus *Alosa* spp. While laboratory analysis was unable to detect to species level, taking a precautionary approach, this may be an indication of twaite shad presence within the freshwater River Thames and that some individuals can pass Teddington Weir, perhaps under appropriate tidal/flow conditions and approach timings.

European Smelt

A.2.234 European smelt are an anadromous species found in coastal waters and frequently in estuaries[65]. The Thames Tideway is understood to support one of the largest-known breeding populations of smelt in the UK[66]. Adult migration typically occurs at the end of winter, with adult smelt known to congregate in the lower Tidal River Thames, near Gravesend, in February and March, prior to moving in shoals into the upstream estuary, after which they spawn on pebble and cobble substrate between Wandsworth Bridge and in proximity to the confluence of the River Wandle (providing a freshwater influence)[67]. Readiness to spawn is assumed to be influenced by thermal regime, tidal, lunar, and potentially olfactory cues. However, this is assumed based on the known sensitivities of salmonids as a precautionary approach. River flow has been observed to have only occasional influence on the triggering of migration but could also play a large role in delaying timings of spawning in populations of the species as found in southwest Scotland[68]. Eggs are often deposited on mosses within the tidal limits of the river, in fast-flowing water that is normally above the saline influence [66], across approximately a six-week period, from mid-February to April in the River Thames[67]. River engineering, including weirs, is known to interrupt upstream migration, preventing adult smelt from reaching spawning habitats. Post-spawning, adults return to the marine environment, where they continue to grow and spawn for up to a further two years. After hatching, young juveniles remain within fresh or brackish water within the estuary and/ or its tributaries from spring to early autumn before moving downstream to join adults in the marine environment.

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A.2.235 EA TRaC survey data rindicates smelt presence throughout the Thames Tideway, with the species recorded at 11 sites within the Upper, Middle, and Lower transitional water bodies and at a further 45 sites within the Thames estuary[69].

A.2.236 Outputs from eDNA surveys conducted over a nine-week repeat sampling period in spring 2022 at eight sampling locations (Putney, Hammersmith; Barnes Bridge, Kew Bridge; Kew Gardens; Richmond; Ham; and Teddington) within the Thames Tideway confirmed the presence and distribution of European smelt eDNA at all eight sites surveyed within the Thames Tideway. Smelt ichthyoplankton and egg surveys were conducted annually as part of the LWR SRO monitoring programme from 2021 to 2024, which identified smelt larvae and eggs between Putney Bridge and Battersea Park within the Thames Tideway suggesting smelt spawn in this area. There is no evidence to suggest smelt spawn above Teddington Weir within the freshwater River Thames.

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Table A.32 Sensitive periods (spawning, egg incubation, and migration) for diadromous species of fish within the River Thames

Migratory Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
European eel (*Anguilla anguilla*) [70, 71, 72, 73, 74]				Upstream migration (elver)					Downstream spawning migration (adult)			
Atlantic salmon (*Salmo salar*) [75, 76, 77, 78, 79]	Spawning & egg incubation		Downstream smolt migration				Upstream spawning migration				Upstream spawning migration / Spawning	
Brown/ sea trout (*Salmo trutta*) [51,80]	Spawning & egg incubation (noting brown trout into March)		Downstream smolt migration				Upstream spawning migration				Upstream spawning migration / Spawning	
European river lamprey* (*Lampetra fluviatilis*) [81, 82]			Upstream spawning migration & spawning		Egg incubation & downstream juvenile movement		Post-metamorphosis downstream migration			Upstream migration (sexually undeveloped adults)		
Sea lamprey (*Petromyzon marinus*) [81, 82]				Upstream migration and Spawning		Egg incubation & downstream juvenile movement	Post-metamorphosis downstream migration					
European smelt (*Osmerus eperlanus*) [83, 84, 85, 86]		Upstream migration / Spawning			Downstream juvenile drifting							
Twaite shad (*Alosa fallax*) [87, 88]				Upstream migration	Spawning		Downstream juvenile drifting					

Key:

Likelihood of scheme operation at river flows of 700, 600, 400 and 300 Ml/d based on the highest modelled return frequency

1:5 years	(yellow)
1:20 years	(purple)
1:50 years	(light orange)
<1:100 years	(grey)

Species Presence

Known to be present upstream of Teddington Weir	(light green)
No evidence of presence upstream of Teddington Weir	(light blue)

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Non-Diadromous Fish Species Assemblage

Coarse Fish Species

A.2.237 Coarse fish spawning times vary between rivers and from year to year, with individuals known to spawn any time between February and August. The earliest spawners known within the reach of interest are dace, pike, and perch, with a range of other species spawning later during the UK coarse fish close season (15th March to 15th June, inclusive). Spawning times for coarse species of interest are provided in Table A.33. With respect to coarse fish species, particularly cyprinid communities, the functional ecology of the dominant species should be considered with respect to flow regime and spawning requirements. Lowland communities are typically dominated by species that have a preference for slow flows, and they typically spawn on aquatic vegetation. However, the influence of flow, specifically the regulation of flow, can alter the balance between rheophilic (fish that prefer fast flwoing water) and limnophilic (fish that prefer still or slow flowing water) assemblages. Several coarse fish species dominate the fish community within the freshwater River Thames, contributing to ~90% of the reported total abundance. However, within the Thames Tideway, coarse fish contribute to ~55% of the reported abundance.

Table A.33 Coarse fish spawning times[89] relative to proposed abstraction scheme timings

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Common bream, *Abramis brama*				2	1	1	2		
Common bleak, *Alburnus alburnus*					1	1	2		
Barbel, *Barbus barbus*			2	1	1	2	2		
Common carp, *Cyprinus carpio*					1	1	2		
Northern pike, *Esox luicus*		2	1	1	2				
Gudgeon, *Gobio gobio*				2	1	1	2		
Eurasian ruffe, *Gymnocephalus cernua*			2	1	1	2	3		
Common dace, *Leuciscus leuciscus*		2	1	1	2				

[89] Environment Agency. (2019). Coarse fishing close season on English rivers – public consultation report.

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Common perch, *Perca fluviatilis*		3	2	1	1	2	3		
Common roach, *Rutilus rutlius*			2	1	1	2			
Zander, *Sander lucioperca*			2	1	1	2			
Common rudd, *Scardinius erythrophthalmus*			2	1	1	2			
Common chub, *Squalius cephalus*				2	1	1	1	2	
Tench, *Tinca tinca*			1	1	1	2			

Key: 1) Peak spawning; 2) Occasionally spawns; 3) Rarely spawns; Note: proposed scheme time colours correspond to the key in Table A.32.

Estuarine Fish Species

A.2.238 Within the freshwater River Thames, only two species of marine/estuarine fish were recorded, flounder and European seabass, and both species utilise tidal stream transport as juveniles to move up the Thames Tideway on a flooding tide to access intertidal feeding areas. As such, it is assumed that the flounder and sea bass recorded within the freshwater River Thames have been able to access the River Thames above Teddington Weir during an extreme high tide event. Flounder are a common occurrence among fish surveys within the freshwater River Thames. However, flounder only account for 0.15% of the catch abundance records within the 2010 to 2023 database. European seabass are not commonly represented among fish surveys within the freshwater River Thames, with one individual juvenile captured downstream of Molesey Weir in September 2023. Whereas in the Thames Tideway, flounder account for 27.8% of catch abundance records and European seabass account for 4.9% of catch abundance records within the 2010 to 2023 database.

A.2.239 Other estuarine species present within the Thames Tideway include common goby, sandy goby, thin-lipped grey mullet, thick-lipped grey mullet, sand smelt and sprat. Typically, all the estuarine fish species spawn further downstream in the estuary or out at sea in the spring with similar timings to coarse fish species. A table of sensitive timings for estuarine species has not been added as it is not anticipated that the Project will impact them.

Thermal preferenda

A.2.240 The thermal preferenda for key fish species within the freshwater River Thames and Tideway Thames (Table A.34) have been derived from a systematic literature review using the 2015 guidance document published by the Department for Environment Food and Rural Affairs (Defra)[90] and the 2013 Natural England (NE) guidance[91]. Temperature preferenda, tolerance zones, and upper lethal temperatures could not be identified for all species, resulting in gaps in the table. Fish species are allocated regional guilds as per previous WFD UKTAG temperature standards research comprising either Lusitanian species or Arctic-Boreal species. Lusitanian species encompass fish from southerly latitudes that are generally warm-water species which are more tolerant of higher temperatures. Arctic-Boreal species encompass fish from northern latitudes with a preference for cold water, meaning they are less tolerant of increasing water temperatures[92].

Table A.34 Temperature preferences, tolerance zones, upper lethal limits and regional guilds for key fish species in the River Thames identified under a literature review

Species/ group	Regional Guild	Temperature preferendum	Tolerance Zone	Upper Lethal Temperature
Atlantic Salmon ***Salmo salar***	Arctic-Boreal	6-20°C[93] 9-17°C[94] 14.0-14.2 °C[95] 18-19°C for parr salmon[96]	7-21.9°C[97]	7-day 27.8°C, 10min 33°C (larval and juvenile); 28°C (22-33°C) adults[98] 27.8°C[94] 27.8 °C[95] 27.8°C[99,] 7 day 27.8°C, 1000 min 29.5°C[100] Salmon parr 7day: 24.8-27.8°C, 10 min 30-33°C[101]
Brown Trout ***Salmo trutta***	Arctic-Boreal	8-17 °C[102] 16°C[103] 12.2-17.6°C[95]	4-19°C[93] Survival as low as 0.4-0.6°C when acclimated to 11°C[104]	23°C[105] 26.4°C[106] 7-day 24.7°C, 10min 30°C (juvenile)[98] 25-27.2°C[94] 1000 min 26.7°C, 7-day 24.7°C[100]

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97 Webb, B. & Walsh, A.J. (2004). Changing UK river temperatures and their impact on fish populations, *Hydrology: Science & Practice for the 21st Century*. 2, pp. 177-191.
98 BEEMS, (2011). 'Thermal Standards for cooling water from new build power stations' *BEEMS*, No.008, pp. 1-147

Species/ group	Regional Guild	Temperature preferendum	Tolerance Zone	Upper Lethal Temperature
European Eel *Anguilla anguilla*	Lusitanian	15.96°C[107]	-	38°C (adult)[108], 32°C[109]
Lamprey Petromyzontidae spp.	Lusitanian	Larvae 13.6°C[110] Larvae 19°C [110]	Larvae up to 19°C[111]	Larvae 31°C[112]
Shad *Alosa spp.*	Lusitanian	-	Larvae 21.5°C[98,113]	Juvenile 35°C[98]
Smelt *Osmerus eperlanus*	Arctic-Boreal	-	-	-
Coarse fish	Lusitanian	~10-25°C[114]	7-30°C[114]	35°C[114]

96 Handeland, S. O., Wilkinson, E., Sveinsbø, b., McCormick, S. D. and Stefansson, S. O. (2008). Temperature influence on the development and loss of seawater tolerance in two fast-growing strains of Atlantic salmon. *Aquaculture*, 233 (1-4), pp. 513-529.

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99 Garside, E.T. (1973) Ultimate upper lethal temperature of Atlantic salmon, *Salmo salar* L. *Canadian Journal of Zoology*, 51(8), pp. 898-900.

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113 Wither *et al.* (2012). Setting new thermal standards for transitional and coastal (TraC) waters, *Marine Pollution Bulletin,* 64(8)

114 Souchon Y.& Tissot, L. (2012). Synthesis of thermal tolerances of the common freshwater fish species in large Western Europe rivers, *Knowledge and Management of the Aquatic Ecosystem*, 403(3).

Fish Swimming Speeds

A.2.241 To better understand fish swimming capabilities, the EA SWIMIT v3.3 tool[115] was used to derive estimated swimming speeds and endurance from available data on known fish species within freshwater River Thames. The following species were available within the SWIMIT tool for inclusion in the assessment:

a. Brown trout
b. Common barbel
c. Common bream
d. Common dace
e. Common chub
f. Common roach
g. European eel including elver lifestage
h. Twaite shad

A.2.242 Data informing the SWIMIT model was originally collated through EA R&D swimming speed experiments[116,117] conducted at Fawley Aquatic Research Laboratories, part of Jacobs, during which burst swimming speeds and endurance times of selected species were measured. Endurance swimming refers to the ability of a fish to swim at a sustained speed for a prolonged period, it primarily uses aerobic metabolic pathways in red muscle fibers. Burst swimming refers to the ability for fish to utilise different muscle blocks within their bodies in order to facilitate burst speeds for brief periods of a minute or less, it relies primarily on anaerobic metabolic pathways using the white muscle fibers.

A.2.243 Fish of different sizes were used in experiments across a representative range of temperatures to inform the limits of both burst speed and sustained endurance swimming. It should be noted that data informing the SWIMIT tool is limited to the testing of fish in size ranges of up to approximately 300 mm in length.

A.2.244 From the SWIMIT tool data, theoretical reference models have been produced, per species, to illustrate fish limits with respect to burst swimming speed, sustained swimming speed, and endurance times in relation to differing water velocities at both 10°C (representative winter water temperature) and 17°C (representative summer water temperature).

[115] Environment Agency. (2006). SWIMIT Version 3.3. Environment Agency National R&D Programme, Project no. W2-026.
[116] Environment Agency (2001). Swimming speeds in fish: Phase 1. R&D Technical Report W2-026/RR1.
[117] Clough, S.C., Lee-Elliott, I.E., Turnpenny, A.W.H., Holden, S.D.J., and Hinks, C. (2004). Swimming Speeds in Fish: phase 2 literature review. Science Project Number: W2-049, Product Code: SCHO0404BIPX-E-P, Environment Agency, Bristol.

A.2.245 Peer-reviewed scientific literature was also included within the assessment, as were flow and water depth preferenda for differing life stages of fish (Table A.35) [118].

Table A.35 Water depth and velocity requirements of UK river fish species across differing life stages (after Cowx et al., 2004) [118]

Species	Life stage	Depth requirement (m)	Velocity requirement (m s^{-1})
Common bream (*Abramis brama*)	Larvae	0.2 - <1.5	<0.05
	Juvenile	<1 - ~1.25	<0.05
	Spawning	0.25 - ~0.5	<0.2
Common bleak (*Alburnus alburnus*)	Larvae	0.2 - <1	<0.05
	Juvenile	<0.2 - >1	<0.05
	Spawning	-	<0.2
European eel (*Anguilla anguilla*)	Juvenile	<6	>0.1
Stone loach (*Barbatula barbatula*)	Juvenile	<0.2	Still – elevated
Common barbel (*Barbus barbus*)	Larvae	< 0.4	<0.2
	Juvenile	<0.2 – 1	still – 1.2
	Adult	-	0.40 – 1
	Spawning	0.15 – 0.4	0.25 – 0.49
European bullhead (*Cottus gobio*)	Juvenile	Shallow	Elevated
	Adult	>0.05 – 0.4	0.1 - >0.4
	Spawning	>0.05 cm	-
Common carp (*Cyprinus carpio*)	Juvenile	Shallow	<0.05
	Spawning	0.8 - 1	

118 Cowx I.G, Noble R.A, Nunn A.D, Harvey J.P, Welcomme R.L, and Halls A.S (2004). Flow and Level Criteria for Coarse Fish and Conservation Species. Report for the Environment Agency. Science Report SC020112/SR.

Species	Life stage	Depth requirement (m)	Velocity requirement ($m\ s^{-1}$)
Northern pike (*Esox lucius*)	Larvae	<1.5	-
	Juvenile	-~1.75	Still
	Spawning	0.5 – 5	<0.05
Three-spined stickleback (*Gasterosteus aculeatus*)	Juvenile	Shallow	Elevated
	Adult	>0.2	Slow
Gudgeon (*Gobio gobio*)	Larvae	Shallow	<0.2
	Juvenile	<0.2 - <1	0 – 0.4
	Adult	-	<0.55
	Spawning	0.05 – 0.08	0.02 – 0.8
Eurasian ruffe (*Gymnocephalus cernua*)	Larvae	0.5	-
Eurasian ruffe (*Gymnocephalus cernua*)	Adult	-	Still
European river Lamprey (*Lampetra fluviatilis*)	Larvae	<1	0.01 – 0.5
	Spawning	0.2 – 1.5	1 - 2
Common dace (*Leuciscus leuciscus*)	Larvae	0.02 – 0.50	<0.025
	Juvenile	<0.5	Still – elevated
	Adult	0.17 – 1.13	0 – 0.57
	Spawning	0.25 – 0.4	0.2 – 0.5
Perch (*Perca fluviatilis*)	Larvae	<1.5	Still or slow
	Juvenile	-~3	
	Spawning	2 – 3	
	Larvae	<0.15 - >0.41	<0.02 - >0.35

Species	Life stage	Depth requirement (m)	Velocity requirement ($m\ s^{-1}$)
Eurasian minnow (*Phoxinus phoxinus*)	Juvenile	<0.35 - >0.53	<0.04 - >0.13
	Adult	0.1 - >0.5	0 - >0.36
	Spawning	0.1 – 0.25	0.2 - 0.3
Common roach (*Rutilus rutilus*)	Larvae	0.20 – 1.5 (<1 preferred)	<0.05 (lentic preferred)
	Juvenile	0.2 - ~1.75 (~0.5 – 1 preferred)	0 – 0.4 (lentic preferred)
	Spawning	0.15 – 0.45	- >0.2
Atlantic salmon (*Salmo salar*)	Larval fish	<0.1 – 0.4 (0.2 preferred)	0.05 – 0.65 (~0.15 – 0.40 preferred)
	0+	<1 (<0.25 preferred)	0.05 – 0.65 (~0.15 – 0.50 preferred)
	Juvenile	0.05 - 1 (~0.2 – 0.4 preferred)	0 - <1 (~0.05 – 0.5 preferred)
	Parr	>0.1 - <1 (~0.25 – 0.6 preferred)	0.04 - <1.2 (~0.1 – 0.6 preferred)
	Spawning	0.15 – 0.91 (~0.25 – 0.5 preferred)	>0.15 – 0.9 (~0.2 – 0.5 preferred
Brown trout (*Salmo trutta*)	Larval fish	0.6	0 - <0.3
	0+	0.2 – 0.3 (~0.2 – 0.3 preferred)	<0.1 – 0.5 (~0.1 – 0.2 preferred)
	Juvenile	0.05 – 2.4 (~0.2 – 0.3 preferred)	0 – 0.44 (<0.25 preferred)
	Parr	0.05 – 3 (~0.4 – 0.75 preferred)	0 – 0.65 (~0.2 – 0.3 preferred)
	Adult	0.09 – 3.05 (~0.4 – 0.75 preferred)	0 – 1.42 (~0.25 preferred)
	Spawning	0.06 – 0.91 (~0.25 – 0.5 preferred)	0.11 – 0.81 (~0.2 – 0.5 preferred)
Common rudd (*Scardinius erythrophthalmus*)	Larvae	Variable	Still
	Juvenile	>1	Still
	Spawning	0.1 – 0.9	<0.05
Common chub (*Squalius cephalus*)	Larvae	0.20 - <1	<0.05
	Juvenile	<0.2 - <1	<0.05

Species	Life stage	Depth requirement (m)	Velocity requirement ($m\ s^{-1}$)
	Spawning	>0 – 1.28	<0.05 – 0.75
Tench (*Tinca tinca*)	Larvae	No preference	Still
	Juvenile	No preference	Still
	Spawning	-	<0.2

A.2.246 The swimming speed analysis was carried out in order to ensure that juvenile coarse fish and European eel elvers do not become impeded by any additional velocity component created by the Project when it is operational and that the migration corridor is maintained within the right-hand bank of the River Thames. A further consideration of the swimming speed assessment was related to any disruption to Atlantic salmon, sea trout, and river lamprey migration.

A.2.247 In relation to the application of the EA SWIMIT V3.3 model, fish older than one year old and adult mature fish have been excluded from the swimming speed assessment, given that they can freely swim away from the Project with little or no influence from the outfall. Currently, fish entering the outfall pipe system is not a concern because of the presence of an internal weir within the current outfall design, which acts as a hard barrier to prevent fish or any backflow from the river from entering the outfall system.

A.2.248 Velocity spawning requirements of several species are of minimal relevance to the Project. Species such as salmonid fish, rheophilic coarse fish and lampreys require shallower conditions where silt-free gravels/cobbles are present or, in the case of some species of coarse fish, established macrophyte beds in order to spawn and lay their eggs. Pelagic eggs or newly hatched fish larvae are not expected to be present within the site of the outfall location, given the distance from known fish spawning areas upstream. Furthermore, recent studies in relation to larval drift suggest that larval fish are able to undertake locomotory movement and behavioural responses post-hatching and actively seek out suitable shallow habitats close to upstream spawning areas[119,120,121].

A.2.249 A key consideration within the fish swimming speed assessment was the potential impacts of the Project in relation to European eel elvers. Within the River Thames catchment, they move as pigmented elvers from the Thames Tideway into the freshwater river at Teddington Weir and then move upstream

[119] Reichard M, Jurajda P, Vaclavik R (2001) Drift of larval and juvenile fishes: a comparison between small and large lowland rivers. Archiv Fu¨ r Hydrobiol–Suppl 135(2-4).
[120] Pavlov D.S. & Mikheev V.N.(2017). Downstream migration and mechanisms of dispersal of young fish in river. Can. J. Fish. Aquat. Sci. 74: 1312–1323
[121] Lechner, A., Keckeis, H., and Humphries, P. 2016. Patterns and processes in the drift of early developmental stages of fish in rivers: a review. Rev. Fish Biol. Fish. doi:10.1007/s11160-016-9437-y.

towards the main tributaries of the River Thames, such as the River Mole, River Wey and River Colne[122].

A.2.250 The SWIMIT model computes swimming speed information for ten fish species, which is summarised in Table A.36. Where SWIMIT fish swimming model output data was not available for the other fish species found within the River Thames and Thames Tideway, fish velocity requirements were supplemented with reference material identified in Table A.35.

Table A.36 Summary of the EA SWIMIT V3.3 fish species and Excel model output

Fish worksheet and relevant life-stage	SWIMIT description
Brown trout	Input/output forms for calculating trout swimming speeds and endurance
Chub	Input/output forms for calculating chub swimming speeds and endurance
Dace 0+ (less than 1 year old)	Input/output forms for calculating 0+ dace swimming speeds and endurance
Dace 1+ (more than 1 year old)	Input/output forms for calculating 1+ dace swimming speeds and endurance
Roach	Input/output forms for calculating roach swimming speeds and endurance
European eel elver	Input/output forms for calculating elver swimming speeds and endurance
European eel	Input/output forms for calculating eel swimming speeds and endurance
Grayling	Input/output forms for calculating grayling swimming speeds and endurance
Barbel	Input/output forms for calculating barbel swimming speeds and endurance
Bream	Input/output forms for calculating bream swimming speeds and endurance
Smelt	Input/output forms for calculating smelt swimming speeds and endurance
Twaite shad	Input/output forms for calculating twaite shad swimming speeds and endurance

A.2.251 As part of the swimming speed assessment, the age of juvenile fish (generally 0+) was taken into consideration for times of the year when the Project is likely to be operational. The size/length of fish species within the SWIMIT model was then considered and compared against known species growth curves[123]. For

[122] Knights, B. (2005). A review of the status of eel populations in the River Thames and its tributaries. Report to Environment Agency Thames Fisheries by the School of Biosciences, University of Westminster, London.
[123] Maitland, P.S & Campbell, R.N. (1992). Freshwater Fishes, New Naturalist series No.75. Published by Collins, ISBN 10: 0002193809ISBN 13: 9780002193801. See Growth Curves within Appendix 3

each species within the SWIMIT model, the maximum sustainable swimming speed as a 90%ile by month was calculated per expected length/size/age.

Statutory and Non-statutory Designated Sites

National Statutory Designated Conservation Sites

Syon Park SSSI

A.2.252 Syon Park SSSI is located approximately 7.3km downstream of the proposed outfall and within 2km of Modgen STW. The site represents one of the largest single remaining areas of floodplain swamp in the Greater London area (22.1ha) and supports wetland invertebrate fauna. The banks of the tidal River Thames at the site are a free from artificial piling and the site is hydrologically connected to the tidal River Thames along the banks and via a series of runnels which are inundated at high tide.

A.2.253 Syon Park is the only known area of tall grass washland along the Thames in Greater London. Tide Meadow at Syon Park consists of a tall wet grassland community of reed-grasses (*Glyceria maxim*a) and (*Phalaris arundinacea)*, which grades into a drier semi-improved grassland of ryegrass (*Lolium perenne)* and rough meadow-grass (*Poa trivialis)* on the higher ground towards the ha-ha.

A.2.254 Along the riverbank, there is a fringe of damp woodland, which is rich in species and hybrids of willow (*Salix)* species and poplar (*Populus)*. Small ditches dissect the site, running from the grassland through the woodland down to the Thames. This part of the river remains tidal, and the intertidal muds are regularly used by herons and visited by flocks of wintering birds.

A.2.255 The site contains a considerable variety of marshland plants, including marsh ragwort *Senecio aquaticu*s, hemlock water dropwort (*Oenanthe crocata)*, water forget-me-not (*Myosotis scorpioides)*, sweet flag (*Acorus calamus)*, yellow flag (*Iris pseudacorus)*, watercress (*Rorippa nasturtium-aquaticum)* and fool's watercress (*Apium nodiflorum)*. However, Himalayan balsam (*Impatiens glandulifera)*, an INNS, is present at the site.

A.2.256 The site is known for having rich invertebrate fauna, with 92 specialist wetland invertebrate species recorded. This is the habitat for a number of uncommon flies, including crane fly (*Cheilotricha imbuta)*, soldier fly (*Stratiomys potamida)*, and the picture-winged fly banded spotwing (*Meliera crassipennis)*. The damp woodland supports wood solderfly (*Xylomia marginata)*, carne fly (*Limonia trivittata)*, and the moth peacock moth (Serniothisa notata). A strong population of the rare German hair snail (*Perforatella rubiginosa)* is present at the site. Syon Park was last assessed in 2017, and both features of the site (invertebrate assemblage of W3 permanent wet mire and lowland wetland including basin fen, valley fen, floodplain fen, and raised bog lagg) were in favourable condition[124][125].

Metropolitan/ County Statutory and Non-statutory Designated Nature Conservation Sites

Isleworth Ait LNR

A.2.257 Isleworth Ait is one of the only remaining areas of undeveloped marginal tidal habitats on the Thames. The site has been designated for the presence of the German hairy snail (*Perforatella rubiginosa)* and its marginal habitat.

River Thames and Tidal Tributaries SINC

A.2.258 The River Thames and Tidal Tributaries SINC boundary runs from just upstream of Platt's Eyot island in Hampton to the confluence with the River Darent in Dartford. The River Thames and the tidal sections of creeks and rivers which flow into it comprise a number of valuable habitats not found elsewhere in London. The mud flats, shingle beach, inter-tidal vegetation, islands and river channel support many species from freshwater, estuarine and marine communities, which are rare in London. The site is of particular importance for wildfowl and wading birds. The river walls, particularly in south and east London, also provide important feeding areas for the nationally rare and specially protected black redstart.

A.2.259 The Thames is extremely important for fish, with over 100 species now present. Many of the tidal creeks are important fish nurseries, including for several nationally uncommon species such as smelt.

A.2.260 In Richmond, Barking Creek supports extensive reed beds. Further downstream are small areas of salt marsh, a very rare habitat in London, where there is a small population of the nationally scarce marsh sow-thistle (*Sonchus palustris*). Wetlands beside the river in Kew support the only London population of the nationally rare and specially protected cut-grass (*Leersia oryzoides*). The numerous small islands in the upper reaches support important invertebrate communities, including several nationally rare snails, as well as a number of heronries. Chiswick Eyot, one of the islands, is a Local Nature Reserve. The towpath in the upper reaches is included in the site and, in places, supports a diverse flora with numerous London rarities, both native and exotic. Ninety per cent of the banks of the tidal River Thames and its creeks are owned by the Port of London Authority, whereas the riparian owners are responsible for the non-tidal (upriver) banks. Nobody owns the water. The Thames Path National Trail follows the River Thames upriver of the Thames Barrier.

A.2.261 In Newham, the river Thames itself includes extensive mudflats which provide feeding areas for birds such as oystercatcher (*Haematopus ostralegus*), shelduck (*Tadorna tadorna*), redshank (*Tringa totanus*) and teal (*Anas crecca*)

[124] Natural England (1984) Site Citation for Syon Park SSSI. (https://designatedsites.naturalengland.org.uk/PDFsForWeb/Citation/1004281.pdf)
[125] Natural England (2017) Syon Park SSSI Condition of Features. (https://designatedsites.naturalengland.org.uk/SiteFeatureCondition.aspx?SiteCode=S1004281&SiteName=Syon%20Park%20SSSI)

with the open water providing habitat for cormorant (*Phalacrocorax carbo*), common tern (*Sterna hirundo*), lesser black-backed gull (*Larus fuscus*) and herring gull (*Larus argentatus*). It also includes the tidal creeks of Bow Creek and Barking Creek. Both support areas of intertidal habitat, including tidal reedbeds of *Phragmites australis* and plants of a more estuarine nature, such as sea aster (*Aster tripolium*) and sea beet (*Beta vulgaris* subsp*. Maritima).*

Priority Habitats

Mudflats

A.2.262 In the tidal River Thames, intertidal mudflats extend from Isleworth Ait to the mouth of the Thames estuary. The mudflats form an important habitat which falls under a number of the designated sites along the Thames, including Isleworth Ait LNR, Syon Park SSSI and the River Thames and Tidal Tributaries SINC. The majority of mudflats are located downstream of Brentford Ait.

Protected and Notable Species

A.2.263 The data from GiGL records from within 2km[126] of the Project draft Order limits showed a total of 36 protected and notable aquatic species. All protected and notable aquatic species identified through the GiGL records search and the other monitoring undertaken are outlined in the sections below.

Mammals

A.2.264 Protected mammal records (four species) from GiGL and monitoring sites are presented in Table A.37.

Fish

A.2.265 Seven designated taxa were identified from fish sampling along the Thames and are also mentioned in the Fish Section of this Appendix and Table A.38.

Aquatic Macroinvertebrates

A.2.266 Twenty-two designated species were identified from macroinvertebrate sampling along the Thames and are listed in Table A.39.

Aquatic Macrophytes

A.2.267 One designated species (flat-leaved pondweed) was identified from macrophyte sampling along the Thames, and a further two from historic records (last recorded 2004) and these species are listed in paragraph A.2.62 and Table A.40.

INNS

A.2.268 Twenty-three INNS were identified within 2km of the draft Order limits along the Thames, and these species are listed in Table A.41 and Table A.42.

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[126] The GiGL records requested during Gate 2 were for a 2km buffer of the proposed development only. This represents the best available data though cannot be spatially verified further.

Table A.37 Protected mammal records from GiGL and monitoring sites within 2km of the draft Order limits

Designation	Taxa Name	Common Name	Site	Date	Abundance	Description
Species Directive Annex 2 and Annex 4 Conservation Regulation 2010 Schedule 2 Wildlife and Countryside Act Schedule 5 Section 9.4a NERC Act Section 41 Local Species of Conservation Concern	*Phocoena phocoena*	Common porpoise	N/A (GiGL record)	2020	1	Harbour Porpoises occupy continental shelf waters typically 20–200 m in depth and are regularly sighted in coastal waters, entering bays and estuaries. Threats come from fishing, acoustic pollution and chemical pollution[127].
Species Directive Annex 2 NERC Act Section 41 Local Species of Conservation Concern	*Phoca vitulina*	Common seal	N/A (GiGL record)	2021	8	Common seal live mostly in the coastal waters of the continental shelf and slope and are commonly found in bays, rivers, estuaries, and intertidal areas. Individuals will haul out on rocks, sand and shingle beaches, sand bars, mud flats, vegetation, sea ice, glacial ice and a variety of man-made structures.

[127] Sharpe, M. & Berggren, P. 2023. Phocoena phocoena (Europe assessment). The IUCN Red List of Threatened Species 2023: e.T17027A219010660. Accessed on 11 December 2024.

Designation	Taxa Name	Common Name	Site	Date	Abundance	Description
						Threats come from industrial and agricultural pollutants, disturbance from offshore renewable energy and overfishing[128].
Species Directive Annex 2	*Halichoerus grypus*	Grey seal	N/A (GiGL record)	2021	6	In the UK, grey seal females give birth on land and show considerable site fidelity, although this is not observed elsewhere. Grey seals are generalists and feed on a range of species. Threats come from fishing and agricultural pollutants[129].
Species Directive Annex 4 Conservation Regulation 2010 Schedule 2 Wildlife and Countryside Act Schedule 5 Section 9.1 NERC Act Section 41	*Balaenoptera acutorostrata*	Minke whale	N/A (GiGL record)	2021	1	Minke whale occurs in both coastal and offshore waters and exploits a variety of prey species in different areas according to availability. Threats to the species come from whaling and fishing activities[130].

[128] Lowry, L. 2016. Phoca vitulina. The IUCN Red List of Threatened Species 2016: e.T17013A45229114. https://dx.doi.org/10.2305/IUCN.UK.2016-1.RLTS.T17013A45229114.en. Accessed on 11 December 2024.
[129] Bowen, D. 2016. Halichoerus grypus. The IUCN Red List of Threatened Species 2016: e.T9660A45226042. https://dx.doi.org/10.2305/IUCN.UK.2016-1.RLTS.T9660A45226042.en. Accessed on 11 December 2024.
[130] Cooke, J.G. 2018. Balaenoptera acutorostrata. The IUCN Red List of Threatened Species 2018: e.T2474A50348265. https://dx.doi.org/10.2305/IUCN.UK.2018-2.RLTS.T2474A50348265.en. Accessed on 11 December 2024.

Table A.38 Protected fish records from GiGL and monitoring sites within 2km of the draft Order limits

Designation	Taxa Name	Common Name	Site	Date	Abundance	Description
NERC Act Section 41 Local species of conservation concern UK Red List Critically Endangered	*Anguilla anguilla*	European eel	N/A (GiGL record)	2017	1	European eel is a migratory species which is facultatively catadromous, living in fresh, brackish and coastal waters but migrating to pelagic marine waters (Sargasso Sea) to breed. While there is some understanding of the eel's continental life history, relatively little is known about its marine phase. Young (glass) eels migrate up waterbodies to grow into elvers and mature into yellow eels which then return to the sea to spawn as silver eels. During the growth phase, eels feed on fish, amphipods and decapod crustaceans. In saline muddy-bottomed habitats, eels forage on bivalves, shrimp, small fish and polychaete worms. Threats include barriers to migration, climate change, habitat loss/degradation, invasive species, parasitism, pollution, predation and unsustainable exploitation[131].
			Molesey - Thames Ditton Island, Upper Main Channel	14/09/2011	5	
				11/09/2012	4	
				10/09/2013	1	
				08/09/2014	2	
				11/09/2015	1	
				09/09/2016	3	
				04/08/2022	1	
				15/09/2010	1	
				16/09/2019	1	
			LTOA Ham Road	21/10/2021	4	
			Molesey main weir pool (EF) (EA site)	19/10/2021	2	
				04/10/2023	3	
			Molesey back weir pool	19/10/2021	1	
			Molesey Weir Pool	08/09/2014	1	
				04/08/2022	2	
				23/08/2011	8	
				19/10/2011	3	
				06/09/2018	1	

[131] Pike, C., Crook, V. & Gollock, M. 2020. Anguilla anguilla. The IUCN Red List of Threatened Species 2020: e.T60344A152845178. https://dx.doi.org/10.2305/IUCN.UK.2020-2.RLTS.T60344A152845178.en. Accessed on 11 December 2024.

Designation	Taxa Name	Common Name	Site	Date	Abundance	Description
Biodiversity Action Plan UK	*Salmo trutta*	Brown trout	Between Sunbury Lock and Surbiton intake	19/10/2021	1	Brown trout inhabit streams, rivers and lakes and spawn in fast-flowing rivers and streams. Trout spawn between late October and March. Adults that survive spawning migrate back downstream in autumn. Fry hatch in between March and July. Maturing into smolts usually happens after 2-3 years and these begin to migrate downstream in April-May when temperatures are 5-11°C. Threats include pollution, dams and other barriers to migration and climate change[132]. Sea trout are individuals of *Salmo trutta* which have migrated out to sea. Sea trout forage in pelagic and littoral habitats, mostly close to the coast, not very far from the estuary of the natal river After at least 18 months at sea, sea trout start to return to rivers to spawn. The pattern and timing of upstream migrations depend on the river, sex and age.
			Molesey Weir Pool	10/09/2013	2	
				08/09/2014	2	
				16/09/2019	1	
				04/08/2022	1	
NERC Act Section 41 UK Red List Vulnerable	*Salmo trutta* subsp. *trutta*	Sea trout	N/A (GiGL record)	2022	1	
Habitats Directive The Conservation (Nature Habitats, etc.) Regulations 1995	*Salmo salar*	Atlantic salmon	Molesey Weir Pool	11/09/2012	1	Atlantic salmon are found in rivers where the water temperature rises above 10°C for at least three months per year and does not exceed 20-25°C for more than a few weeks in summer. In the River Thames individuals will return as early as July every year. Juveniles and resident stream populations
				16/09/2019	1	

[132] Freyhof, J. 2024. Salmo trutta. The IUCN Red List of Threatened Species 2024: e.T19861A58301467. Accessed on 13 December 2024.

Designation	Taxa Name	Common Name	Site	Date	Abundance	Description
OSPAR Convention Biodiversity Action Plan UK The Conservation of Habitats and Species Regulations 2010						inhabit riffles of fast-flowing, moderately cold streams and rivers. Eggs are laid in gravel in water temperatures less than 10°C (6°C is optimum). Fry usually emerge from gravel between April and June when the temperature rises above 8°C. Individuals mature in freshwater and then begin to adapt to salt water as a smolt and migrate downstream in March-June when the temperature increases above 8-10°C from low winter levels. After spending between one and four winters at sea, individuals migrate to their natal river to breed. Threats come from hydropower, water pollution, sedimentation, changes in flows and temperature, barriers, fish farming, changes in sea temperature and currents and fishing[133]. For more information see the Salmonids Baseline section.
Habitats Directive The Conservation of Habitats and Species	*Barbus barbus*	Barbel	Molesey Weir Pool	14/09/2011	1	Barbel occur in premontane to lowland reaches of clear, warm, medium-sized to large rivers with fast currents and gravel bottom, occasionally in lakes. Adults often shoal, hiding under overhanging trees or bridges during the day. They are most active during dusk and dawn. Barbel overwinter often in large aggregations. Spawning takes
				11/09/2012	2	
				10/09/2013	1	
				08/09/2014	3	
				11/09/2015	6	
				10/09/2016	5	
				16/09/2019	2	

133 Darwall, W.R.T. 2023. Salmo salar. The IUCN Red List of Threatened Species 2023: e.T19855A67373433. https://dx.doi.org/10.2305/IUCN.UK.2023-1.RLTS.T19855A67373433.en. Accessed on 13 December 2024.

Designation	Taxa Name	Common Name	Site	Date	Abundance	Description
Regulations 2010				04/08/2022	2	place in May-July when temperatures reach 15°C. Individuals will spawn on gravels/cobbles in flow water. Feeding larvae drift a short distance from the spawning site to shallow shoreline habitats. Larvae and juveniles are benthic in very shallow shoreline habitats, which they leave for faster-flowing waters as they grow. Threats to the species come from water pollution and river regulation[134].
			Molesey - Thames Ditton Island, Upper Main Channel	08/09/2014	1	
				11/09/2015	3	
				06/09/2018	1	
			Molesey main weir pool (EF) (EA site)	04/10/2023	1	
Habitats Directive	*Cottus gobio*	Bullhead	LTOA Ham Road	21/10/2021	1	Bullhead is a small, bottom-dwelling species that predominantly inhabits riffles and other shallow stretches of streams and minor rivers containing cool, clear, running water and coarse stony substrata such as gravel or small cobbles. Adult individuals are territorial and employ visual threat displays and sounds to defend their chosen sites. This leads to spatial segregation, with larger individuals occupying the most favourable territories. It is understood to be relatively sedentary, with a low dispersal ability. Threats come from water pollution, groundwater abstraction, gravel extraction, barriers, canalisation of river channels and the introduction of invasive fish species[135].
			Molesey main weir pool (EA site)	04/09/2023	1	
			Molesey main weir pool (EF) (EA site)	19/10/2021	1	
			Molesey main weir pool (EF) (EA site)	04/10/2023	1	

[134] Freyhof, J. 2024. Barbus barbus. The IUCN Red List of Threatened Species 2024: e.T2561A58293571. Accessed on 13 December 2024.
[135] Ford, M. 2024. Cottus gobio. The IUCN Red List of Threatened Species 2024: e.T259224371A135085385. Accessed on 13 December 2024.

Designation	Taxa Name	Common Name	Site	Date	Abundance	Description
Habitats Directive, The Conservation Regulations 1995, England, Biodiversity Action Plan UK The Conservation of Habitats and Species Regulations 2010	*Lampetra sp.*	Ammocoete lamprey	Molesey main weir pool (EF) (EA site)	04/10/2023	3	There are three species of lamprey in the UK: brook (*L. planeri*), river (*L. fluviatilis*) and sea lamprey (*Petromyzon marinus*). All species inhabit streams and rivers with clean, flowing water, soft substrates of sand, silt or mud, and sometimes submerged vegetation. River and sea lamprey are anadromous and will migrate into rivers from coastal or marine environments to spawnin in cobbles/gravels. Brook lamprey spend their whole lives in freshwater. Juveniles are blind and spend several years buried in soft sediments. Metamorphosis occurs at the end of this growth stage, at which point individuals develop functional eyes and eventually emerge from the substrate as short-lived, non-trophic adults which spawn and die. Reproduction occurs between March and May when water temperatures rise above 9°C. Threats come from river management, barriers, river sediment extraction, water pollution, fish stocking and climate change[136]. See the European River Lamprey and Sea Lampry Baseline Sections for more information.
		Smelt	Battersea Beam Trawl	17/06/2010		Smelt are pelagic inhabitants of marine waters, estuaries and large lakes. Spawning
			Battersea Beam Trawl	14/09/2018	2	

[136] Ford, M. 2024. Lampetra planeri. The IUCN Red List of Threatened Species 2024: e.T11213A135088684. Accessed on 13 December 2024.

Designation	Taxa Name	Common Name	Site	Date	Abundance	Description
Biodiversity Action Plan UK	*Osmerus eperlanus*		Battersea Seine Net	17/06/2010	7	in rivers take place on sand, gravel, stones and plant material, preferably in fast-flowing water. Anadromous individuals spawn at two years of age. Spawning migration begins in March/April when water temperatures are around 4-12°C in the lower reaches of rivers. Eggs hatch in 20-35 days, and larvae drift downstream into estuaries. After spawning, adults migrate to the sea and remain in coastal waters close to estuaries. In the River Thames spawning take place within the tidal limits in fast-flowing water between mid-February – April. Threats come from water pollution, river impoundment and climate change.[137] For more information see the European Smelt Baseline Section.
				17/06/2010	3	
				30/09/2010	1	
				30/09/2010	74	
				03/06/2011	50	
				03/06/2011	5	
				30/09/2011	4	
				30/09/2011	1	
				25/09/2013	2	
				25/09/2013	9	
				05/06/2015	9	
				20/09/2016	1	
				20/09/2016	24	
				22/09/2017	122	
				22/09/2017	1	
				14/09/2018	5	
				14/09/2018	28	
				21/06/2019	85	
				20/09/2019	1	
				20/09/2019	3	
				16/06/2022	5	
				18/10/2022	5	
				02/10/2023	3	
				02/10/2023	3	

[137] Freyhof, J. 2024. Osmerus eperlanus. The IUCN Red List of Threatened Species 2024: e.T15631A135090814. Accessed on 13 December 2024.

Designation	Taxa Name	Common Name	Site	Date	Abundance	Description
			Chiswick Beam Trawl	16/06/2010	5	
				29/09/2010	3	
				12/09/2018	2	
			Chiswick Seine Net	16/06/2010	8	
				16/06/2010	6	
				29/09/2010	1	
				29/09/2010	62	
				02/06/2011	63	
				14/06/2013	1	
				14/06/2013	89	
				24/09/2013	2	
				24/09/2013	1	
				16/09/2016	3	
				12/09/2018	2	
				12/09/2018	155	
				19/09/2019	46	
				13/10/2022	3	
			Kew Beam Trawl	28/09/2010	1	
				11/09/2018	1	
			Kew Kick sample	01/06/2011	18	
			Kew Seine Net	10/06/2010	2	
				28/09/2010	2	
				28/09/2010	2	
				01/06/2011	9	
				12/06/2013	2	

Designation	Taxa Name	Common Name	Site	Date	Abundance	Description
				12/06/2013	2	
				11/09/2018	3	
				11/09/2018	26	
				18/09/2019	71	
			Richmond Seine Net	31/05/2011	1	

Table A.39 Designated macroinvertebrate species recorded from EA data and Ricardo monitoring data within 2km of the draft Order limits

Designation	Taxa Name	Common Name	Site	Date	Abundance	Description
Nationally Scarce. Includes Red Listed taxa	*Unio tumidus*	Swollen river mussel	LRUS 005/ EA 35900	25/05/2006	1	Swollen river mussel is nationally scarce, is found in freshwater rivers and is generally concentrated in marginal zones where the substrate is firm and muddy. It is also found in slower-flowing environments like canals, drainage channels, and some lakes. The species is mostly restricted to lowland watercourses and requires cleaner and better-oxygenated waters than other *Unio* species. This species is sensitive to water pollution and artificial river modifications[138].
				28/09/2010	2	
				18/10/2013	1	
				05/10/2022	1	
			LRUS 006/ EA 188056	03/11/2017	3	
				21/05/2019	1	
				26/10/2021	2	
				05/10/2022	1	
			LRUS 007	10/10/2022	5	
			LRUS 008	26/10/2021	2	

[138]Van Damme, D. 2011. Unio tumidus. The IUCN Red List of Threatened Species 2011: e.T156111A4898810. https://dx.doi.org/10.2305/IUCN.UK.2011-2.RLTS.T156111A4898810.en. Accessed on 03 December 2024.

Designation	Taxa Name	Common Name	Site	Date	Abundance	Description
			LRUS 008	13/10/2022	1	
Nationally Scarce. Includes Red Listed taxa	*Sphaerium rivicola*	River orb mussel	LRUS 005/EA 35900	07/11/2006	22	River orb mussel habitat preference is for deeper parts of rivers and canals, and it prefers muddy sediments and low current velocities. It has a very low tolerance to pollution. It has been found in waterways that receive very little water pollution, specifically decreases in dissolved oxygen concentrations and water over 0.3% Cl salinity. The INNS Asian clam (*Corbicula fluminea*) is a threat to the species locally due to competition[139].
Red listed based on 2001 IUCN guidelines – Vulnerable				28/09/2010	1	
				13/04/2023	1	
			LRUS 008	13/10/2022	1	
			98142	10/08/2006	5	
			98142	19/06/2007	1	
Global Red List status - Vulnerable	*Pseudanodonta complanata*	Depressed river mussel	LRUS 005/ EA 35900	28/09/2010	1	Depressed river mussel is found in deep (>1m) parts of rivers and has a preference for silt-sandy substrate. Threats to the species include water pollution, eutrophication, siltation, channelization, habitat disturbance and habitat loss through abstraction, drought and poaching. Climate change may threaten the species through increases in hypoxic conditions, algal

[139] Van Damme, D. 2011. Sphaerium rivicola. The IUCN Red List of Threatened Species 2011: e.T155853A4855157. http://dx.doi.org/10.2305/IUCN.UK.2011-2.RLTS.T155853A4855157.en Accessed on 03 December 2024

Designation	Taxa Name	Common Name	Site	Date	Abundance	Description
						blooms and stratification (most relevant to lakes)[140]. Depressed river mussel is believed to use a number of fish species as hosts in its larval life stage, including ruffe, perch, three-spined stickleback and brown trout. Depressed river mussel is a UK Biodiversity Action Plan (BAP) species[141]. The INNS zebra mussel (*Dreissena polymorpha*) is a threat to depressed river mussel[142].
Nationally Scarce. Includes Red Listed taxa	*Viviparus contectus*	Lister's river snail	LRUS 008	10/03/2022	1	Lister's river snail live in lentic habitats, in large slow-flowing rivers and large drainage ditches. Threats include eutrophication, alterations to water courses, changes to flow regimes and dredging[143].
UK Red List Data Deficient	*Stagnicola palustris/fuscus/corvus*	Marsh pond snail	N/A	Last recorded 2012	3	Marsh pond snail is much rarer than the taxa within the *Stagnicola* complex

[140] Depressed River Mussel Pseudanodonta complanata has most recently been assessed for The IUCN Red List of Threatened Species in 2011. Pseudanodonta complanata is listed as Vulnerable under criteria A2ace+4ace.
[141] McIvor A.L. and Aldridge D.C. (2007) The Reproductive Biology of the Depressed River Mussel, *Pseudoanodonta complanata* (Bivalvia: *Unionidae*), with Implications of its Conservation. Journal of Molluscan Studies DOI: 10.1093/mollus/eym023 · Source: OAI
[142] Ożgo M, Urbańska M, Hoos P, Imhof HK, Kirschenstein M, Mayr J, Michl F, Tobiasz R, von Wesendonk M, Zimmermann S, Geist J. Invasive zebra mussel (Dreissena polymorpha) threatens an exceptionally large population of the depressed river mussel (Pseudanodonta complanata) in a postglacial lake. Ecol Evol. 2020 Apr 12;10(11):4918-4927. doi: 10.1002/ece3.6243. PMID: 32551070; PMCID: PMC7297777.
[143] Lister's River Snail Viviparus contectus has most recently been assessed for The IUCN Red List of Threatened Species in 2014. Viviparus contectus is listed as Least Concern.

Designation	Taxa Name	Common Name	Site	Date	Abundance	Description
			(GiGL record)			currently recognised in Britain[144]. These species are associated with large lowland rivers, which are slow-flowing and standing waterbodies (lakes and ponds)[145].
Red listed based on 2001 IUCN guidelines - Vulnerable	*Stenelmis canaliculata*	Riffle beetle	LRUS 005/ EA 35900	07/11/2006	1	This riffle beetle is a lowland species found in deep water with gravel and stones in lakes and rivers. It is a truly benthic organism and shares an association with the riverine habitats occupied by barbel (*Barbus barbus*)[146].
			98142	27/05/2005	1	
Red listed based on 2001 IUCN guidelines - Near Threatened	*Macronychus quadrituberculatus*	Riffle beetle	LRUS 006/ EA 188056	22/05/2023	1	This riffle beetle is a lowland species, usually found clinging to submerged tree trunks in deep, permanent water in rivers. The larva is wireworm-like and burrows into wet wood, where it pupates. As such the species is associated with frequent riparian trees and/or shaded conditions,
			98142	18/03/2009	1	
			98142	29/03/2021	1	

144 Seddon M.B, Killeen I.J. and Fowles A.P. (2014) A Review of the Non-Marine Mollusca of Great Britian: Species Status No.17. NRW Evidence Report No:14, 84pp, Natural Resources Wales.
145 Beran L. (2008) A contribution to distribution of genus *Stagnicola* and *Catascopia* (Gastropoda: Lymnaeidae) in the Czech Republic. Malacologica Bohemoslovaca 7: 70-73.
146 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.

Designation	Taxa Name	Common Name	Site	Date	Abundance	Description
						pebbles/gravel bed substrate and a run, riffle or glide river habitat[147]. Threats to the species come from water pollution (particularly decreases in dissolved oxygen), siltation, the canalisation of rivers, and, of course, the loss of woody debris[148].
Nationally Scarce	*Hydrovatus clypealis*	Water beetle	N/A (GiGL record)	Last recorded 2004	2	This water beetle has a preference for standing waterbodies (ponds and ditches), muddy substrate and marginal vegetation[149].
LPS Local species of conservation concern UK Red List Vulnerable	*Somatochlora metallica*	Brilliant emerald dragonfly	N/A (GiGL record)	Last recorded 2022	1	The brilliant emerald dragonfly is generally found in lakes, ponds and slow-flowing streams, which are not too nutrient enriched. Adults associate with water margins, which are shaded by trees. Females lay eggs in shallow, muddy areas or among floating vegetation. The larvae live in bottom material under overhanging trees and other objects that shade the water.

[147] Johns T. (2005) A study of the aquatic riffle beetle *Macroinychus quadrituberculatus* on the holy brook, Berkshire. University of Bristol dissertation.
[148] 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.
[149] Scheers K. (2017) Hydrovatus clypealis Sharp, 1876 expands its distribution to Belgium, with an update on the distribution of H. cuspidatus (Kunze, 1818) (Coleoptera: Dytiscidae)

Designation	Taxa Name	Common Name	Site	Date	Abundance	Description
UK Red List Near Threatened	*Libellula fulva*	Scarce chaser	N/A (GiGL record)	Last recorded 2016	1	The scarce chaser is associated with lowland river floodplains which are slow flowing. The species requires good water quality, as well as submerged, floating, and emergent macrophytes. Adults require shrubs and trees. Threats include pollution, eutrophication, inappropriate river management and heavy boat traffic[150].
UK Red List Data Deficient	*Sympetrum striolatum*	Common darter	N/A (GiGL record)	Last recorded 2020	87	Common darter has a preference for still or brackish water. Adults are frequently found away from water in woodland rides[151].
Red listed based on 2001 IUCN guidelines - Vulnerable	*Ephemera lineata*	Striped mayfly	LRUS 005/ EA 35900	30/09/2014	2	Striped mayfly larvae live in pools and margins of large rivers, where they dig into the substrate to form a tubular burrow. Larvae feed by filtering or collecting fine particulate organic detritus from the water column. This species has a two-year life cycle, and the emergence of the adults probably takes place at dusk or dawn on the surface of the water or occasionally on
			LRUS 006/ EA 188056	22/05/2023	1	
			N/A (GiGL record)	Last recorded 2010	1	
			98142	15/03/2005	1	
				20/10/2005	2	
				20/11/2005	1	

[150] British Dragonfly Society (no date) Scarce Chaser. (https://british-dragonflies.org.uk/species/scarce-chaser/)
[151] British Dragonfly Society (no date) Common Darter. (https://british-dragonflies.org.uk/species/common-darter/)

Designation	Taxa Name	Common Name	Site	Date	Abundance	Description
				14/06/2006	1	a stick, stone, or plant stem partially or entirely out of the water. The species is only confirmed to be present in the UK on the River Thames and the River Wye. It is most widespread on the River Thames. Threats to the striped mayfly come from water pollution, dredging, channel modifications and removal of bank vegetation. Adults are attracted to light and may be attracted to bankside lighting or surfaces that reflect horizontally polarized light (examples include asphalt roads and solar panels)[152].
				08/11/2006	4	
				17/12/2007	3	
				18/03/2009	1	
				21/09/2009	10	
				18/03/2010	1	
				14/06/2010	4	
				18/10/2010	1	
				08/12/2014	1	
				09/11/2021	1	
UK Red List Data Deficient	*Psychomyia fragilis*	Caddisfly	N/A (GiGL record)	2014	1	Only confidently recorded from chalk/limestone districts in Cumbria, Yorkshire, Derbyshire and South-East England. Records confirmed by adults are only from England and from travertine depositing streams and rivers. Suspected problems with the larval key mean that single records from many other sites are probably

[152] MACADAM, C.R. 2016. A review of the status of the mayflies (Ephemeroptera) of Great Britain - Species Status No.28. Natural England Commissioned Reports, Number193

Designation	Taxa Name	Common Name	Site	Date	Abundance	Description
						incorrect[153]. It is possible this record on the Thames is incorrect.
Red listed based on 2001 IUCN guidelines - Vulnerable	*Oxycera analis*	Dark-winged soldier fly	LRUS 009	09/03/2022	1	The dark-winged soldier fly is distributed throughout lowland England. Adults occur in fen and fen carr and by spring-fed pools and streams on calcareous rocks, either in deciduous woodlands or at wood margins. The aquatic larvae have been collected from silt at the margins of small calcareous streams, where they live in the very shallow water film. Threats come from nutrient enrichment, water abstraction, and drainage of wetlands[154].
Nationally Scarce. Includes Red Listed taxa	*Gyraulus laevis*	Smooth ramshorn	98142	20/09/2005	1	The smooth ramshorn snail lives in shallow water of lakes and ponds, which are rich in vegetation[155].
			98142	20/03/2006	2	
			98142	12/12/2006	2	
Nationally Notable	*Kageronia fuscogrisea*	Brown Mayfly	98142	30/12/2008	1	The brown mayfly is a lowland species that inhabits lakes, ponds, and slow-flowing streams and rivers. The
			98142	24/06/2009	1	

153 WALLACE, I.D. 2016. A review of the status of the caddis flies (Trichoptera) of Great Britain -Species Status No.27. Natural England Commissioned Reports, Number191.
154 DRAKE, C.M. 2017. A review of the status of Larger Brachycera flies of Great Britain - Species Status No.29. Natural England Commissioned Reports, Number192.
155 Gloer P. (2024) *Gyraulus laevis* and *G. parvus* (Mollusca:Gastropoda), two distinct species. Ecologica Montenegrina 71: 237-239

Designation	Taxa Name	Common Name	Site	Date	Abundance	Description
						species is associated with mud/clay substrate and macrophytes[156].
Near Threatened	*Metalype fragilis*	Caddisfly	98142	19/06/2007	1	*M. fragilis* is associated with the middle reaches of alkaline rivers, with stony/ cobble substrates predominate and medium conductivity[157].
Red list nationally scarce	*Oecetis notata*	Caddisfly	98142	13/07/2018	1	*O. notata* is associated with moss and large rocks in moderately flowing rivers[158].
			98142	27/07/2021	1	
			98142	04/05/2022	1	
Red list nationally scarce	*Omphiscola glabra*	Pond mud snail	LRUS 013	27/10/2021	1	The pond mud snail is known to colonise acidic temporary and permanent waterbodies[159].
Nationally notable	*Sisyra terminalis*	Caddisfly	98142	08/11/2006	1	*S. terminalis* can be found along large running rivers as well as still-water bodies like canals, ditches and lakes[160].
Vulnerable	*Valvata macrostoma*	Large-mouthed valve snail	98142	20/11/2005	1	The large-mouthed valve snail is known to occur mostly in drainage ditches in southern Britain. The species has a preference for emergent
			98142	18/04/2006	4	

156 Vilenca M., Ternjej I. and Mihaljevic Z. (2021) What is new in Croatian mayfly fauna? Nat. Croat.: 30 (1) 73–83, 2021, Zagreb.
157 Kelly-Quinn M., Bradley C., Murray D., Tierney D., Ashe P., Bracken J. and McGarrigle M. (2003) Physio-chemical characteristics and macroinvertebrate communities of the Caher river. National University of Ireland, Dublin.
158 Jenkins R. A. (1977) A record of *Oecetis notata* (Rambur) (Trichoptera: Leptoceridae) from south-west Wales. Entomologist's Record and Journal of Variation 52-53.
159 Vignoles P., Dreyfuss G. and Rondelaud D. (2017) Detection of habitats colonized by *Omphiscola glabra* (Gastropoda: Lymnaeidae) on acid soils using indicator plants. Limnology Journal: 53 (261-269)
160 Levente. A., A study on the Hungarian freshwater osmylid and sponge-flies fauna (Neuroptera: Osmylidae, Sisyridae).

Designation	Taxa Name	Common Name	Site	Date	Abundance	Description
						vegetation and may be associated with higher chloride concentrations (ditches with a tidal influence), and the species can tolerate low dissolved oxygen levels[161]

Table A.40 Designated macrophytes recorded from EA data and Ricardo monitoring data within 2km of the draft Order limits

Designation	Taxa Name	Common Name	Site	Date	Abundance	Description
Red listing based on 2001 IUCN guidelines- Near Threatened	*Potamogeton friesii*	Flat-stalked pondweed	LR 05	12/09/2023	1	Flat-stalked pondweed occurs in open, shallow, neutral to basic water with slow flow, including lakes and ponds[162]. Threats to the species include eutrophication, channel modifications, disturbance from boat traffic and dredging[163].
Local species of Conservation Concern UK Red List Endangered	*Limosella aquatica*	Mudwort	N/A (GiGL record)	Last recorded 2004	15	Mudwort is found on exposed mud of temporary pools and stream banks. As a semi-aquatic plant, it grows in moist or wet ground habitats, including damp hollows, in mud and wet sand next to water and partly submersed or floating in shallow depths around pools, lakes, streams and ditches. It is thought that habitat loss is a threat to the species[164].

[161] Watson A. (2002) The Ecology of Four Scarce Wetland Molluscs. Environment Agency, Almondsbury Bristol.
[162] Flat-stalked Pondweed Potamogeton friesii has most recently been assessed for The IUCN Red List of Threatened Species in 2015. Potamogeton friesii is listed as Least Concern.
[163] Helcom (2019) Species Information Sheet Potamogeton friesii. (https://helcom.fi/wp-content/uploads/2019/08/HELCOM-Red-List-Potamogeton-friesii.pdf) Accessed 03 December 2024
[164] Botanical Society of Britain and Ireland BSBI (no date) *Limosella aquatica* L., Mudwort. (https://fermanagh.bsbi.org/limosella-aquatica-l)

Designation	Taxa Name	Common Name	Site	Date	Abundance	Description
Local species of conservation concern UK Red List Vulnerable	*Persicaria minor*	Small water-pepper	N/A (GiGL record)	Last recorded 2004	23	Small water-pepper has a preference for disturbed, enriched habitats in lowland still and running water bodies. This species occurs on open, gravelly or sandy, marshy ground, which is liable to intermittent flooding, ponds, and ditches[165].

Table A.41 Invasive Non-native (INNS) macrophytes recorded from EA data and Ricardo monitoring data within 2km of the draft Order limits

Taxa Name	Common Name	Site ID	Occurrence / Survey date	Percentage Cover Band	Description
Acorus calamus	Sweet flag	LR 05	17/09/2020	1	Sweet flag has a preference for shallow, nutrient-rich waterbodies. Will colonise river margins and standing waterbodies[166].
Azolla filiculoides	Water Fern	LR 06	13/09/2023	1	Water fern has a preference for still and slow-moving lowland waterbodies. The species will grow at any depth but is not tolerant of waves or faster-flowing water. The potential range of the species is restricted by altitude and temperature. Increase in temperature due to climate change may make some areas more suitable for colonisation. Water ferns are easily spread due to their size, which is due to the movement of other plants, boat traffic, and recreational water users.[167]
		LRUS 005/ EA 35900	14/09/2023	1	

[165] Botanical Society of Britain and Ireland BSBI (no date) *Persicaria minor* (Huds.) Opiz, Small Water-pepper. (https://fermanagh.bsbi.org/persicaria-minor-opiz)
[166] Schou J.C., Moeslund B., van de Wyer K., Lansdown R.V., Wiegleb G., Holm P.,Baastrup-Spohr L. and Sand-Jensen K. (2023) Aquatic Plants of Northern and Central Europe including Britain and Ireland. Princeton University Press
[167] NNSS (2011) GB Non-Native Organism Risk Assessment Scheme *Azolla filiculoides* – Water fern. (https://www.nonnativespecies.org/assets/Uploads/RA_Azolla_filliculoides_Water_Fern.pdf) Accessed 04 December 2024

Taxa Name	Common Name	Site ID	Occurrence / Survey date	Percentage Cover Band	Description
Elodea canadensis	Canadian Pondweed	LR 05	17/09/2020	2	Canadian waterweed has a preference for nutrient-rich still or slow-flowing waterbodies but will persist in areas with faster flow. The plant is easily spread through vegetation fragments[168].
Elodea nuttallii	Nuttall's waterweed	LR 04	17/09/2020	3	See Canadian waterweed description.
		LR 04	12/09/2023	3	
		LR 05	17/09/2020	3	
		LR 05	12/09/2023	4	
		LR 06	13/09/2023	2	
		LR 07	17/09/2020	1	
		LR 07	17/09/2020	5	
		LR 07	14/09/2023	2	
		LRUS 004	12/09/2023	1	
		LRUS 005/ EA 35900	08/08/2011	1	
		LRUS 005/ EA 35900	17/08/2017	1	
		LRUS 005/ EA 35900	14/09/2023	2	
		LRUS 006	14/09/2023	4	
Gunnera tinctoria	Giant Rhubarb	LR 05	12/09/2023	1	Giant rhubarb has a preference for higher temperatures and is predominantly distributed in the south-west of the UK. The plant can be found in a number of habitats but requires moist soil. It can be found in riparian zones of waterbodies

[168] NNSS (2015) Non-native Species Information Portal Canadian Waterweed *Elodea canadensis* (https://www.nonnativespecies.org/non-native-species/information-portal/view/1303) Accessed 04 December 2024

Taxa Name	Common Name	Site ID	Occurrence / Survey date	Percentage Cover Band	Description
					and can tolerate water-logged soil. The large plant shades out native species and can grow from rhizome fragments[169].
Hydrocotyle ranunculoides	Floating pennywort	LR 05	12/09/2023	1	Floating pennywort has a preference for eutrophic slow-flowing water bodies. This species can displace native species through shading due to its ability to form dense mats. It can also change flows and dissolved oxygen levels. The plant can reproduce from fragments of vegetation[170].
		LRUS 005/ EA 35900	17/08/2017	1	
		LRUS 005/ EA 35900	14/09/2023	1	
Impatiens capensis	Orange balsam	LR 05	12/09/2023	2	Orange balsam primarily colonises most habitats along lowland rivers and still waterbodies in central and southern England. The plant can disperse through seeds[171].
		LR 07	14/09/2023	1	
		LRUS 006	14/09/2023	1	
Lemna minuta	Least duckweed	212973	26/07/2023	1	Least duckweed has a preference for standing and slow-flowing waterbodies. The plant is easily transferred between waterbodies due to its size[172].
		LR 04	17/09/2020	1	
		LR 06	13/09/2023	2	
		LR 07	17/09/2020	1	
		LR 07	17/09/2020	1	
		LRUS 005/ EA 35900	17/08/2017	1	
		LRUS 005/ EA 35900	14/09/2023	1	

[169] Newman J. and Duenas-Lopex M. (2015) GB Non-Native Organism Risk Assessment Scheme for *Gunnera spp. (G. manicata & G. tinctoria)* (https://www.nonnativespecies.org/assets/Uploads/RSS_RA_Gunnera_spp-v2.pdf) Accessed on 04 December 2024
[170] NNSS (no date) GB Non-Native Organism Risk Assessment Scheme *Hydrocotyle ranunculoides* (https://www.nonnativespecies.org/assets/Uploads/RA_Hydrocotyle_ranunculoides_Floating_PennywortFINAL.pdf) Accessed 04 December 2024
[171] Dehnen-Schmutz K. (2022) GB Non-Native Organism Risk Assessment Scheme Orange balsam (*Impatiens capensis)*. NNSS (https://www.nonnativespecies.org/assets/Uploads/Impatiens_capensis_orange_balsam_RA_.pdf) Accessed 04 December 2024
[172] NNSS (2019) Non-native Species Information Portal Least Duckweed *Lemna minuta*. (https://www.nonnativespecies.org/non-native-species/information-portal/view/1940) Accessed 04 December 2024

Table A.42 Invasive non-native (INNS) macroinvertebrates recorded from EA data and Ricardo monitoring data within 2km of the draft Order limits

Taxa Name	Common Name	Site ID	Occurrence / Survey date	Survey abundance	Description
Branchiura sowerbyi	Tubificid worm	LRUS 006/ EA 188056	21/05/2019	44	In cooler temperate regions, this tubificid worm is found most frequently in artificially warmed waters, where it usually occurs in shallow, very warm, stagnant or slowly flowing waters in sediment/ silt[173].
Chelicorophium curvispinum	Caspian mud shrimp	LRUS 005/ EA 35900	25/05/2006	3	Caspian mud shrimp lives in fresh and brackish water and has a preference for hard surfaces such as rocks, wood, submerged vegetation and bivalve shells. This species is able to reproduce up to three generations per year. It builds mud tubes on hard substrates, which can lead to surfaces becoming totally covered by fine matter removed by the animals from the water column as a result of their filtering activity, which can impact species that colonise fine substrates[174].
			07/11/2006	1	
			28/09/2010	25	
			29/05/2013	12	
			18/10/2013	13	
			15/04/2014	15	
			30/09/2014	65	
			26/10/2021	7	
			05/10/2022	1	
			13/04/2023	1	
		LRUS 006/ EA 188056	09/05/2017	23	
			03/11/2017	16	
			21/05/2019	3	
			26/10/2021	5	
			05/10/2022	1	

[173] Grabowski M. and Janlonska A. (2009) First record of *Branchiura sowerbyi* Beddard, 1892 (Oligochaeta: Tubificidae) in Greece. Aquatic Invasions 4 (2) 365-367
[174] Mastitsky S. (2009) Chelicorophium curvispinum (Caspian mu shrimp). CABI Compendium URL **https://doi.org/10.1079/cabicompendium.108307** Accessed 03 December 2024

Taxa Name	Common Name	Site ID	Occurrence / Survey date	Survey abundance	Description
			13/04/2023	1	
			22/05/2023	4	
		LRUS 004	26/10/2021	11	
			05/10/2022	2	
		LRUS 007	26/10/2021	15	
			10/10/2022	2	
		LRUS 009	26/10/2021	5	
		LRUS 008	10/03/2022	1	
			26/10/2021	10	
			13/10/2022	2	
Corbicula fluminea	Asian clam	LRUS 005/ EA 35900	29/05/2013	1	Asian clam inhabits the sediments of oligotrophic to eutrophic streams, rivers, lakes, and irrigation and drainage cuts. It is common on oxygenated muddy to sandy sediments but also occurs among gravel and cobbles. Individuals are able to spread and self-fertile easily and can produce more than one brood a year. Habitats range from shallow, essentially lentic environments to relatively wide, deep, flowing rivers and associated channels. The species occupies a range of substrates, preferring sand and gravel to mud.
			26/10/2021	17	
			26/04/2022	1	
			05/10/2022	27	
			13/04/2023	34	
			13/07/2023	86	
			26/10/2023	37	
		LRUS 006/ EA 188056	09/05/2017	400	
			03/11/2017	30	
			21/05/2019	14	
			26/10/2021	13	
			25/04/2022	12	
			05/10/2022	22	
			13/04/2023	8	
			22/05/2023	25	

Taxa Name	Common Name	Site ID	Occurrence / Survey date	Survey abundance	Description
			13/07/2023	16	The species is tolerant of a wide temperature range, high salinity, high nutrients and low dissolved oxygen levels[175].
			26/10/2023	8	
		LRUS 004	26/10/2021	21	
			25/04/2022	7	
			05/10/2022	4	
		LRUS 007	26/10/2021	34	
			10/03/2022	5	
			10/10/2022	3	
		LRUS 008	26/10/2021	35	
			10/03/2022	16	
			13/10/2022	168	
		LRUS 009	26/10/2021	23	
			26/10/2023	8	
Crangonyx pseudogracilis	Northern river amphipod	LRUS 007	10/03/2022	2	Northern river amphipod can inhabit a wide range of habitats, including lakes, permanent and temporary ponds, rivers, streams and even interstitial habitats. It can tolerate saline conditions, a wide temperature range, poor water quality, and low dissolved oxygen, and it can occupy polluted areas that other native species cannot colonise[176].
		LRUS 009	26/10/2023	5	
		LRUS 005/ EA 35900	07/11/2006	12	
			28/09/2010	1	

[175] Non-Native Species Information Portal (2015) Asiatic Clam *Corbicula fluminea*. (https://www.nonnativespecies.org/non-native-species/information-portal/view/897)
[176] Non-Native Species Information Portal (2011) Northern River Crangonyctid *Crangonyx pseudogracilis.* (https://www.nonnativespecies.org/non-native-species/information-portal/view/1010)

Taxa Name	Common Name	Site ID	Occurrence / Survey date	Survey abundance	Description
Crangonyx pseudogracilis/ floridanus	Florida Crangonyx	LRUS 006/ EA 188056	09/05/2017	20	See the description for the northern river amphipod.
		LRUS 007	10/10/2022	2	
Dikerogammarus haemobaphes	Demon shrimp	LRUS 005/ EA 35900	18/10/2013	27	Demon shrimp can be found in a broad range of conditions but prefers solid substrates, macrophytes, and filamentous algae in rivers, lakes, and canals. It can tolerate salinities of up to 8 and is able to tolerate temperatures up to 30°C. Demon shrimp predate and out-compete native shrimp species The species shows a preference for habitats dominated by zebra mussel (*Dreisseina polymorpha*) and the presence of this species may facilitate the spread of demon shrimp[177].
			30/09/2014	200	
			26/10/2021	7	
			05/10/2022	39	
			13/07/2023	21	
			13/04/2023	9	
		LRUS 006/ EA 188056	09/05/2017	250	
			03/11/2017	5	
			21/05/2019	180	
			26/10/2021	21	
			25/04/2022	10	
			05/10/2022	16	
			13/04/2023	7	
			22/05/2023	180	
			13/07/2023	9	
			26/10/2023	9	
		LRUS 004	26/10/2021	41	
			25/04/2022	22	
			05/10/2022	17	
		LRUS 007	26/10/2021	32	

[177] Aldridge D.C. (2013) Non-native Organism Rapid Risk Assessment for Dikerogammarus haemobaphes (Eichwald, 1841). https://www.nonnativespecies.org

Taxa Name	Common Name	Site ID	Occurrence / Survey date	Survey abundance	Description
		LRUS 008	26/10/2021	9	
			10/03/2022	1	
			13/10/2022	83	
		LRUS 009	26/10/2021	5	
			05/07/2023	14	
Dreissena bugensis	Quagga mussel	LRUS 006/ EA 188056	09/05/2017	3	Quagga mussels have a preference for lentic systems (lakes and reservoirs) and will colonise hard substrates. They will reproduce when water temperatures reach 10˚C and can tolerate brackish water[178].
			26/10/2023	1	
		LRUS 004	26/10/2021	2	
		LRUS 008	26/10/2021	9	
		LRUS 008	10/03/2022	12	
		LRUS 005/ EA 35900	13/07/2023	1	
			26/10/2023	3	
		LRUS 009	26/10/2023	6	
Dreissena polymorpha	Zebra mussel	LRUS 005/ EA 35900	25/05/2006	2	Zebra mussels prefer still and slow-flowing watercourses. This species can affect native species through smothering and outcompeting individuals. Their filter feeding reduces the abundance of phytoplankton and increases water clarity. Biofouling from this species can also block or impeed the functioning of infrastructure such as intakes and pipes and have implications to the native ecology. This impact can cause changes in macrophyte and
			07/11/2006	2	
			30/09/2014	1	
			26/10/2021	5	
			13/04/2023	1	
			26/10/2023	8	
		LRUS 006/EA 188056	09/05/2017	13	
			03/11/2017	5	
			21/05/2019	2	

[178] NNSS (2015) Risk Assessment Summary Sheet Quagga Mussel (*Dreissena rostriformis)*
(https://www.nonnativespecies.org/assets/Uploads/RSS_RA_Dreissena_rostriformis_bugensis.pdf)

Taxa Name	Common Name	Site ID	Occurrence / Survey date	Survey abundance	Description
			26/10/2021	4	macroinvertebrate populations, which can have knock-on effects for fish and birds[179].
			13/04/2023	2	
			13/04/2023	1	
			22/05/2023	3	
			13/07/2023	1	
			26/10/2023	1	
		LRUS 004	26/10/2021	1	
		LRUS 008	26/10/2021	2	
			13/10/2022	3	
		LRUS 009	26/10/2021	2	
			26/10/2023	13	
Dugesia tigrina	American immigrant triclad	LRUS 006/ EA 188056	05/10/2022	2	See description for American immigrant triclad (*Girardia tigrina*) below.
		LRUS 008	13/10/2022	2	
Ferrissia californica	Wautier's Limpet	LRUS 005/ EA 35900	05/10/2022	2	Wautier's limpet (*Ferissia californica*) has a preference for slow-flowing and standing water and requires good water quality. The species may be able to self-fertilise[180].
		LRUS 008	13/10/2022	15	
Girardia tigrina	American immigrant triclad	LRUS 006/ EA 188056	09/05/2017	1	This American immigrant triclad species can colonise standing and slow-flowing water bodies. It will attach itself to aquatic plants and tolerate both soft and hard channel substrates.
		LRUS 006/ EA 188056	22/05/2023	3	

[179] NNSS (2010) GB Non-Native Organism Risk Assessment Scheme *Dreissena polymorpha* – Zebra Mussel. (https://www.nonnativespecies.org/assets/Uploads/RA_Dreissena_polymorpha_Zebra_Mussel.pdf) Accessed on 04 December 2024
[180] Mabrouki Y., Gloer P. and Taybi A.F. (2023) The First Record of the North American Freshwater Limpet *Ferrissia californica* (Mollusca, Gastropoda) in Morocco. Nature Conservation Research 8 (1) 108-112.

Taxa Name	Common Name	Site ID	Occurrence / Survey date	Survey abundance	Description
					The species can tolerate temperatures of 9-25°C. It is predatory and will feed on small invertebrates[181].
Hypania invalida	Ponto-Caspian polychaete Worm	LRUS 005/ EA 35900	28/09/2010	1	The Ponto-Caspian polychaete worm will colonise the river up to a depth of 1m and will inhabit sand, gravel and silt sediments[182].
			29/05/2013	10	
			18/10/2013	1	
			05/10/2022	1	
			13/07/2023	14	
			26/10/2023	1	
		LRUS 006/ EA 188056	03/11/2017	142	
			21/05/2019	926	
			22/05/2023	50	
			13/07/2023	3	
			26/10/2023	2	
		LRUS 009	26/10/2023	9	
Menetus dilatatus	Trumpet ramshorn	LRUS 004	25/04/2022	2	Trumpet ramshorn has a preference for ponds, swamps, and river margins, as well as under rocks, aquatic vegetation, and woody debris. The species is tolerant of acidic waters and impoverished habitats[183].

[181] Ilic M.D., Tubic B.P., Marinkovic N.S., Markovic V.M., Popvic N.Z., Zoric K.S., Rakovic M.J. and Paunovic M.M. (2018) First Report on the Non-Indigenous Triclad *Girardia tigrina* (Girarg, 1850) (Tricladida, Dugesiidae) in Serbia, with Notes on its Ecology and Distribution. Aca Zoologica Bulgarica 70 (1) 39-43.
[182] Pabis K., Krodkiewska M and Cebulska K. (2017) Alien freshwater polychaetes *Hypania iinvalida* (Grube 1860) and *Laonome calida* Capa 2007 in the Upper Odra River (Baltic Sea catchment area). Knowledge & Management of Aquatic Ecosystems 418.
[183] Quinonero-Salgado S. and Lopez-Soriano J. (2022) First Record of Menetus dilatatus (Gould, 1841) (Gastropoda: Planorbidae) for Spain. Elona, Revista De Malacologia Iberica 3, 21-24.

Taxa Name	Common Name	Site ID	Occurrence / Survey date	Survey abundance	Description
Musculium transversum	Long fingernail clam	LRUS 009	26/10/2023	1	The long fingernail clam can be found in ephemeral and standing waterbodies and rivers. It is tolerant of poor water quality. These filter feeders can impact suspended matter, and their pseudofeces can impact sediments[184].
Physella acuta	Bladder Snail	LRUS 005/ EA 35900	25/05/2006	1	The bladder snail has a high growth rate. The species can tolerate nutrient-enriched waterbodies, temporary waterbodies and a wide range of temperatures and salinity. It does not appear to have any preferences for particular habitats and is widely distributed throughout the world[185].
			05/10/2022	7	
		LRUS 006/ EA 188056	05/10/2022	1	
		LRUS 007	10/10/2022	1	
		LRUS 009	11/10/2022	3	
		LRUS 008	13/10/2022	4	
Potamopyrgus antipodarum	New Zealand Mudsnail	LRUS 005/ EA 35900	25/05/2006	40	The New Zealand mudsnail is tolerant of most environments and inhabits almost all aquatic habitats, including rivers and streams, standing waterbodies and estuaries. This species tolerates siltation, high nutrients, drought conditions and temporary desiccation. It prefers littoral zones in lakes or slow streams with silt and organic matter substrates but will tolerate high-flow environments where it can burrow into the sediment.
			07/11/2006	210	
			28/09/2010	29	
			29/05/2013	46	
			18/10/2013	58	
			15/04/2014	34	
			30/09/2014	8	
			26/04/2022	1	
			05/10/2022	715	
			13/04/2023	1	

[184] Way C.M. (1989) Dynamis of Filter-Feeding in Musculium transversum (Bivalvia: Sphaeriidae). Journal of the North American Benthological Society 8 (3) 243-249.
[185] Anderson R. (2003) Physella (Costatella) acuta Draparnaud in Britain and Ireland – Its taxonomy, origins and relationships to other introduced Physidae. Journal of Conchology 36: 7-21

Taxa Name	Common Name	Site ID	Occurrence / Survey date	Survey abundance	Description
			13/07/2023	78	It can establish very dense populations and can consume large amounts of primary production, alter ecosystem dynamics, outcompete native invertebrates, and negatively influence higher trophic levels[186].
			26/10/2023	62	
		LRUS 006/ EA 188056	09/05/2017	800	
			03/11/2017	3130	
			21/05/2019	145	
			26/10/2021	4	
			05/10/2022	330	
			13/04/2023	3	
			22/05/2023	145	
			13/07/2023	73	
			26/10/2023	24	
		LRUS 004	26/10/2021	3	
			25/04/2022	2	
			05/10/2022	203	
		LRUS 007	26/10/2021	9	
			10/03/2022	4	
			10/10/2022	276	
		LRUS 008	26/10/2021	8	
			10/03/2022	4	
			13/10/2022	247	
		LRUS 009	26/10/2021	11	
			09/03/2022	7	

[186] NNSS (2019) Jenkin's Spire Snail, New Zealand Mudsnail *Potamopyrgus antipodarum*. (https://nonnativespecies.org/non-native-species/information-portal/view/2811) Accessed 05 December 2024

Taxa Name	Common Name	Site ID	Occurrence / Survey date	Survey abundance	Description
			11/10/2022	88	
			05/07/2023	138	
			26/10/2023	9	

SRO Aquatic INNS Risk Assessment Tool (SAI-RAT)

A.2.269 An SRO Aquatic INNS Risk Assessment Tool (SAI-RAT), which considers the risk of transfer of INNS for the raw water transfer element of the Teddington DRA Project is outlined in Appendix 6.4. SAI_RAT assessments provide a quantitive risk assessment of the liklihod of a raw water transfer transferring INNS through a schemes operation.

A.2.270 The Teddington DRA Project was assessed using two operating scenarios. The existing TLT scheme was also assessed for comparison. The assessment showed the existing TLT scheme had an Inherent Risk Score for INNS of almost double that of the Teddington DRA Project. However, it must be noted that the abstraction from the Teddington DRA Project may add additional potential to transfer INNS on top of the existing abstraction, so no transfer of new INNS is expected.

Freshwater River Thames (Walton Intake to Teddington Weir)

A.2.271 The INNS baseline data are based on specific surveys targeting INNS at four locations within the freshwater River Thames between Walton Intake and Teddington Weir. Surveys were completed in the summer of 2021 and then in the spring and summer of 2022 and 2023. This comprised a Multi-Habitat Survey and eDNA sampling, locations for these can be found in Table A.43. Additional eDNA samples were taken at one further site.

Table A.43 Targeted INNS survey locations

Study Area	Site Name	NGR
Freshwater River Thames	LRUS 007	TQ 1187868995
	LRUS 008	TQ 1318169115
	LRUS 009	TQ 1723571341
Tidal River Thames	LRUS 011	TQ 1640771795
	LRUS 012	TQ 1711474993
	LRUS 013	TQ 1842677610
	LRUS 014	TQ 1935077695
	LRUS 015	TQ 2172777782

A.2.272 The data set has been supplemented by data from wider project-specific surveys that have been completed within the study area, including invertebrate, macrophyte, fish and depressed river mussel surveys.

A.2.273 It was further supplemented with publicly available data from the National Biodiversity Network (NBN) Atlas, with records from 250m of the study area within the last 20 years (2004 to 2024) included in the study.

A.2.274 A total of 40 INNS relevant to the SAI-RAT assessment were recorded during the Project-specific monitoring and in wider NBN and project data, as can be seen in Table A.44. There were 22,153 individual records of INNS within this section of the freshwater River Thames. The bulk of this number was made up of the two most frequently recorded species: Asian clams (*Corbicula fluminea*), followed by the New Zealand mud snail (*Potamopyrgus antipodarum*). The third most common species was the demon shrimp (*Dikerogammarus haemobaphes*). Counts of each species in this section can be seen in Table A.44 below.

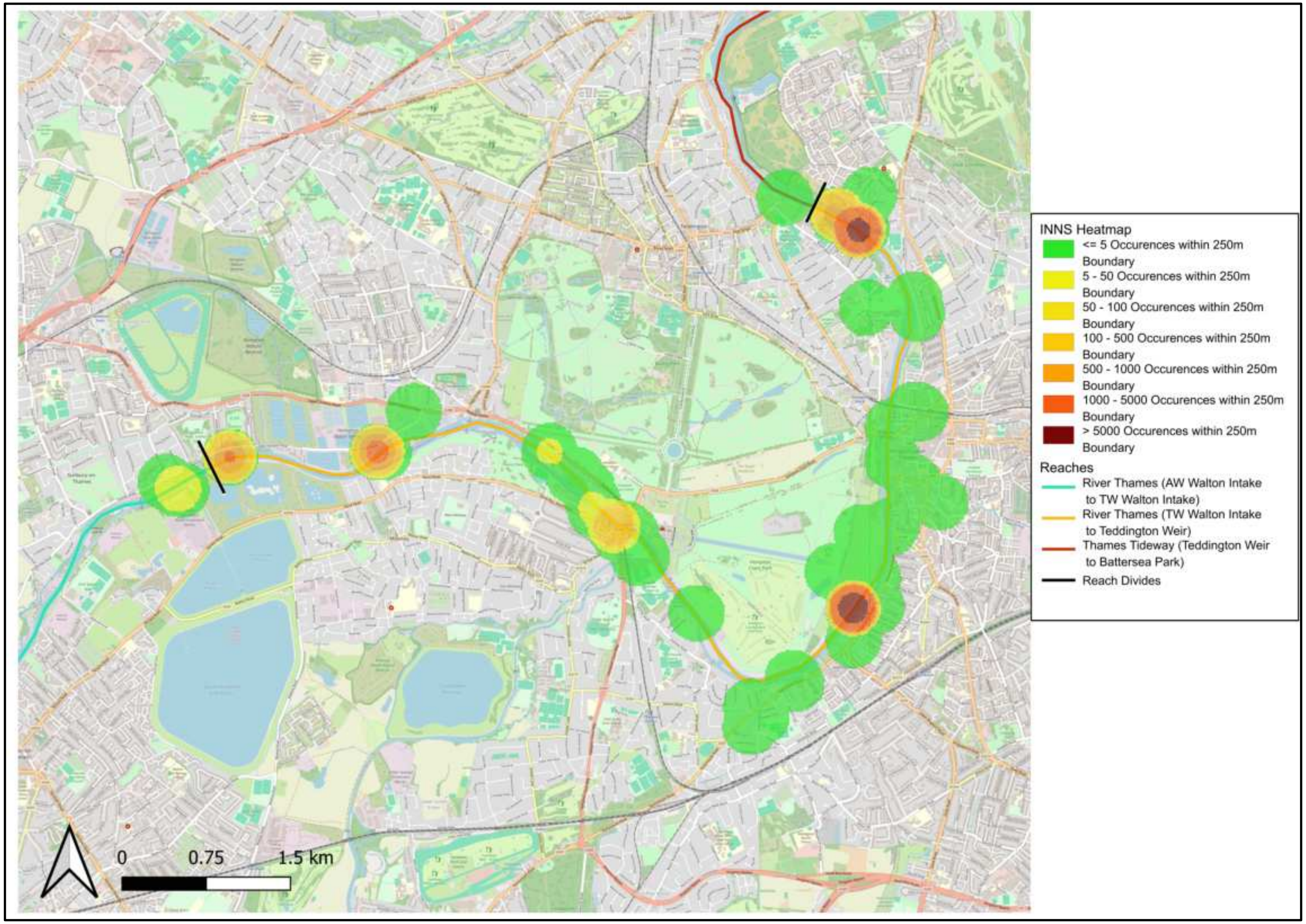
A.2.275 Plate A.81 shows the distribution of INNS within this section of the freshwater River Thames. There are INNS records at varying densities, which encompass the majority of this reach. There are two locations with over 5000 occurrences of INNS. The first of these is located in Surbiton at Kingston Island (Ravens Ait), and the second is just upstream of Teddington Lock. There are two further locations between 1000 and 5000 records, which are both located in the upper section of the reach close to Hampton Water Works. It must be noted that the areas of highest densities coincide with the locations of several of the Project's INNS monitoring sites, as well as the wider surveys such as depressed river mussel surveys and invertebrate sampling

Table A.44 INNS recorded in freshwater River Thames (Thames Walton Intake to Teddington Weir)

Species	Common Name	Count (No of records from all data sets)
Acorus calamus	Sweet Flag	1
Azolla filiculoides	Water Fern	2
Branchiura sowerbyi	Tubificid worm	50
Chelicorophium curvispinum	Caspian mud shrimp	477
Chelicorophium robustum	Corophium shrimp	1
Chelicorophium sp.	Corophium shrimp	2
Corbicula fluminea	Asian Clam	9096
Crangonyx pseudogracilis	Northern river amphipod	7
Crangonyx pseudogracilis/floridanus	Florida Crangonyx	47
Ctenopharyngodon idella	Grass Carp	1
Cyprinus rubrofuscus	Amur Carp	1
Dikerogammarus haemobaphes	Demon shrimp	1671
Dreissena bugensis	Quagga Mussel	37
Dreissena polymorpha	Zebra Mussel	196
Dreissena rostriformis bugensis	Quagga Mussel	274

Species	Common Name	Count (No of records from all data sets)
Dugesia tigrina	Planarian	4
Elodea canadensis	Canadian Waterweed	4
Elodea nuttallii	Nuttall's Waterweed	49
Eriocheir sinensis	Chinese Mitten Crab	30
Fallopia japonica	Japanese Knotweed	6
Ferrissia californica	California Limpet	17
Gammarus tigrinus	Tiger Shrimp	1
Girardia tigrina	American immigrant triclad	4
Glossiphonia verrucata	Freshwater leach	1
Gunnera tinctoria	Giant Rhubarb	1
Hemimysis anomala	Bloody Red Shrimp	1
Hydrocotyle ranunculoides	Floating Pennywort	16
Hypania invalida	Bristle worm	1388
Impatiens capensis	Orange Jewelweed	8
Lemna minuta	Least Duckweed	9
Menetus dilatatus	Trumpet ramshorn	2
Musculium transversum	Fingernail Clam	1
Oncorhynchus mykiss	Rainbow Trout	1
Pacifastacus leniusculus	Signal Crayfish	7
Physella acuta	Bladder Snail	18
Physella acuta/gyrina	Bladder Snail	114
Potamogeton nodosus	Longleaf Pondweed	1
Potamopyrgus antipodarum	New Zealand Mud Snail	8586
Sander lucioperca	Zander	19
Stenelmis canaliculata, larva	Riffle Beetle Larva	1
Grand Total		22153

Plate A.81 INNS Heatmap in Freshwater River Thames (Thames Walton Intake to Teddington Weir)



Estuarine River Thames (Teddington Weir to Battersea)

A.2.276 INNS data is based on specific surveys targeting INNS at five locations within the Tidal Thames (Teddington Weir to Battersea). Surveys were completed in the summer of 2021, then in the spring and summer of 2022 and 2023. This comprised a Multi-Habitat Survey and eDNA sampling.

A.2.277 The data set has been supplemented by data from wider project-specific surveys that have been completed within the reach, including invertebrate, macrophyte and fish surveys.

A.2.278 It was further supplemented with publicly available data from the NBN Atlas, with records from within 250m of the river within the last 20 years (2004 to 2024) included in the study.

A.2.279 A total of 43 INNS of interest were recorded during the Project-specific monitoring and in wider NBN and project data, as can be seen in Table A.45. There were 19,739 individual records of INNS within this section of the Estuarine Thames. The bulk of this number was made up of the two most frequently recorded species: Asian clams (*Corbicula fluminea*), followed by the New Zealand mud snail (*Potamopyrgus antipodarum*). The third most common species was the demon shrimp (*Dikerogammarus haemobaphes*).

A.2.280 Plate A.82 shows the distribution of INNS within this section of the Estuarine River Thames. There are INNS records at varying densities, which encompass the majority of this reach. There is one location with over 5000 occurrences of INNS, located just downstream of Teddington Lock. There are several more locations with records between 100 and 500, including Richmond Lock, Kew Gardens and Chiswick Eyot. It must be noted that the areas of highest densities coincide with the locations of several of the Project's INNS monitoring sites, as well as the wider invertebrate sampling.

INNS within 2km of the draft Order limits

A.2.281 A further 184 individual records from the 2km area around the draft Order Limits were recorded, comprising 19 species. The most abundant species from this area were the Chinese mitten crab (*Eriocheir sinensis*) and Himalayan balsam (*Impatiens glandulifera*).

A.2.282 Plate A.82 shows the distribution of INNS records across the 2km area. The distribution of INNS across this study area is at much lower densities compared to the River Thames study areas. It must be noted that no project-specific surveys were undertaken across this wider 2km boundary, and data is only publicly available data from the NBN atlas.

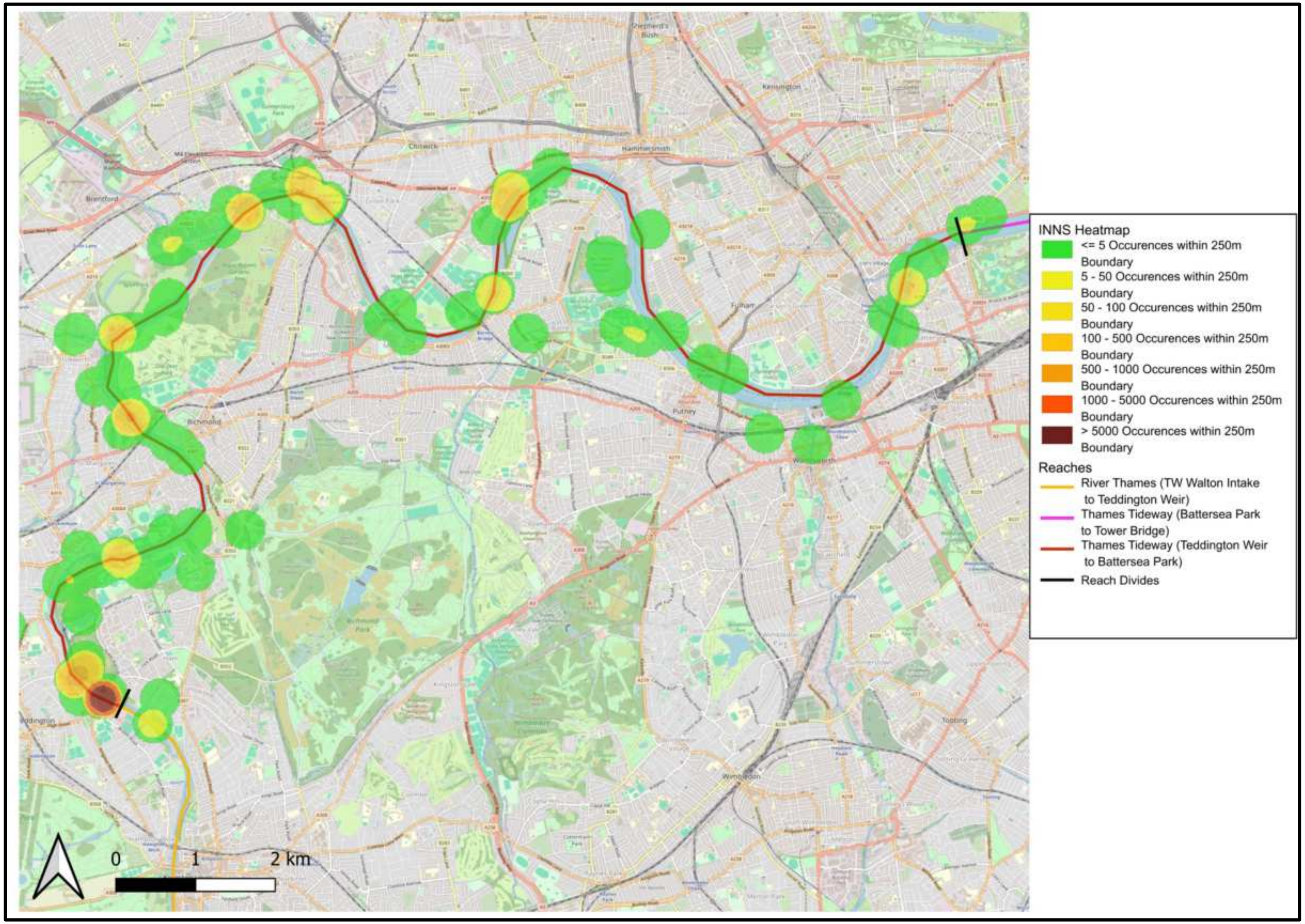
Table A.45 INNS Records within the Estuarine River Thames (Teddington Weir to Battersea)

Species	Common Name	Number of records within 2km of draft Order limits	Number of records within 10km of the draft Order limits
Ailanthus altissima	Tree of heaven	1	
Azolla filiculoides	Red water fern	1	
Branchiura sowerbyi	Tubificid worm		13
Chelicorophium curvispinum	Curly-spined amphipod	2	1,137
Corbicula fluminea	Asian Clam	101	976
Cordylophora caspia	Athecate hydroid		8
Crangonyx pseudogracilis	Freshwater Shrimp	1	1
Crangonyx pseudogracilis/floridanus	Freshwater Shrimp		375
Cyprinus rubrofuscus	Amur Carp		1
Dikerogammarus haemobaphes	Demon Shrimp	3	1024
Dreissena polymorpha	Zebra Mussel	8	306
Dreissena rostriformis bugensis	Quagga Mussel		15
Dugesia tigrina	American immigrant triclad		143
Elodea canadensis	Canadian Waterweed		3
Elodea nuttallii	Nuttall's Waterweed		15
Eriocheir sinensis	Chinese Mitten Crab	62	302
Fallopia japonica	Japanese Knotweed	30	12
Ferrissia wautieri	European Limpet		1
Gammarus tigrinus	Tiger Shrimp		50

Species	Common Name	Number of records within 2km of draft Order limits	Number of records within 10km of the draft Order limits
Girardia (Dugesia) tigrina	Tiger Flatworm	1	17
Hemimysis anomala	Bloody Red Shrimp		3
Heracleum mantegazzianum	Giant Hogweed	2	1
Hyacinthoides hispanica	Spanish Bluebell		3
Hydrocotyle ranunculoides	Floating Pennywort	14	15
Hypania invalida	Freshwater Polychaete		1194
Impatiens capensis	Orange Jewelweed	3	2
Impatiens glandulifera	Himalayan Balsam	33	29
Lemna minuta	Least Duckweed		2
Lysichiton americanus	Yellow skunk cabbage	9	
Marenzelleria viridis	Red gilled mudworm		1
Menetus dilatatus	Trumpet ramshorn		3
Musculium transversum	Fingernail Clam		1
Neomysis integer	Opossum Shrimp		13
Oncorhynchus mykiss	Rainbow Trout		3
Pacifastacus leniusculus	Signal Crayfish		8
Palaemon longirostris	Long-clawed Prawn		96
Pelophylax ridibundus	Marsh Frog		1
Physella acuta	Bladder Snail	1	62
Physella acuta/gyrina	Bladder Snail		9
Planaria torva	Flatworm		3

Species	Common Name	Number of records within 2km of draft Order limits	Number of records within 10km of the draft Order limits
Potamopyrgus antipodarum	New Zealand Mud Snail	2	13876
Rhododendron ponticum	Common Rhododendron		1
Sander lucioperca	Zander		13
Talitridae	(sandhoppers)		1
Trachemys scripta	Red-eared slider	1	
Total			19,922

Plate A.82 INNS Heatmap within the Estuarine River Thames (Teddington Weir to Battersea)



Thames Water