Appendix 5B
Lower River Lee Floating River Vegetation Survey

OFFICE OF PUBLIC WORKS

Lower Lee (Cork City) Drainage Scheme

FLOATING RIVER VEGETATION SURVEY

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1. Introduction

Triturus Environmental consultants were appointed by Ryan Hanley consulting engineers to undertake a floating river vegetation survey on the Lower River Lee catchment between Innishcarra Dam and Cork City as part of ecological surveys prepared for the Lower Lee (Cork City) Drainage Scheme. The survey was required to assess the distribution and diversity of Floating River Vegetation (hereafter FRV) along the footprint of proposed flood relief works. Floating river vegetation is designated in the EU Habitats Directive (92/43/EEC) as an Annex I Habitat, *Water courses of plain to montane levels, with submerged or floating vegetation of the Ranunculion fluitantis and Callitricho-Batrachion (low water level during summer) or aquatic mosses* (3260). In light of its inclusion as an annexed habitat under the EU Habitats Directive, there is a legal obligation to protect it. It must be highlighted however, that this habitat is very widespread in Ireland by virtue of the presence of *Ranunculus* species and *Fontanalis* moss, both of which are ubiquitous in faster flowing Irish Rivers.

The flood relief works proposed on the Lower River Lee may result in increased flow volumes during periods of peak discharge which may or may not alter the distribution of the FRV community within the river. As FRV distribution is controlled in part by flow rates, it is necessary to map the distribution of the habitat in advance of any works commencing. Preliminary distribution surveys were undertaken during September 2014 to map the spread of the habitat in the Lower River Lee. However, given the time of year it was not possible to speciate *Ranunculus* vegetation and the full spread of the FRV community could not be established given that it was outside the optimum growth period (i.e. June-July). This was considered because flowering parts are no longer present by September and the *Ranunculus* stands start to fragment as a result of vegetative reproduction prior to the winter floods. Additionally detailed information on the factors defining better quality and poorer quality FRV zones within the river needed to be established in more comprehensive follow up surveys. Survey work was thus undertaken at the end June 2015 to establish the extent of the FRV community during the full growth cycle (including flowering plants). By characterising zones of importance for the FRV habitat, areas that represent better quality habitat could be identified to provide an indicator of conditions where optimal habitat for the annexed habitat exist. By examining projected annual exceedence probabilities (5 year return period or 20% annual exceedance probability) between the baseline and design levels relative to the important FRV zones, potential impacts to the FRV community could be hypothesised.

Classification of Floating River Vegetation

The definition of what determines a good representation of the Annex I Habitat, *Water courses of plain to montane levels, with submerged or floating vegetation of the Ranunculion fluitantis and Callitricho-Batrachion (low water level during summer) or aquatic mosses (3260),* has not yet been defined clearly in Ireland. Therefore, the interpretation of the habitat relative to good reference conditions deemed to be optimal remains difficult. Specifically the following species have been named in the interpretation manual of European Habitats (EU Commission, 2007) for Water courses of plain to montane levels with the Ranunculion fluitantis and Callitricho-Batrachion (3260); *Ranunculus saniculifolius, R. trichophyllus, R. fluitans, R. peltatus, R. penicillatus ssp., R. pseudofluitantis, R. aquatilis, Myriophyllum spp., Callitriche spp., Sium erectum, Zannichellia palustris, Potamogeton spp.* and *Fontinalis antipyretica.*

Given that *Ranunculus* species, *Calitriche* species and *Fontanalis* moss are among the species defining the habitat, the distribution of the habitat may thus be considered very widespread in Ireland given that these groups are ubiquitous in Irish running waters (Kelleher, 2011).

The abundance and diversity of plants in a floating river vegetation community would act as a proxy for the condition of the habitat as aprior mentioned (Hatton-Ellis & Grieve, 2003). High quality reference conditions

can thus be identified for each floating river vegetation ecotype which can be compared with other rivers falling into the same category to evaluate the condition and future prospects of these habitats.

Floating river vegetation has been divided into 7 river categories in the UK excluding Northern Ireland (Hatton-Ellis & Grieve, 2003). The application of these classes however have not been adopted in Ireland given that *Ranunculus* species, including *Ranunculus penicillatus* subsp. *penicillatus*, have different tolerances in Ireland than in the UK (Webster, 1991; Kelleher, 2011), making comparisons difficult.

Further studies carried out by Kelleher (2011) to examine whether categorization was possible in an Irish context failed to achieve robust classification between different rivers supporting FRV habitat and thus no subdivision by river ecotype was achieved, as in the U.K. The broad definition of FRV habitat without classification into sub habitat types and associated definitions of its national status means it will prove difficult to monitor and to evaluate its conservation status regionally and nationally. Nonetheless in the most rudimentary way, the presence of indicator FRV species such as *Ranunculus* which are considered a 'keystone' habitat in salmonid rivers certainly are representative of the community, albeit not as diverse as the FRV communities of an English chalk stream for example.

Current Status & Importance of FRV in Ireland

According to the Status of EU Protected Species and Habitats in Ireland 2013, the status of Floating River Vegetation [3260] has changed from 'Bad Status' to 'Inadequate Status' (NPWS 2013). The reason for the shift in categories relates to a requirement for greater knowledge of the classification and distribution of the habitat based on a clear Irish classification system. The principal threats to the habitat are considered as arterial drainage and agricultural nutrient enrichment which can result in sedimentation and lowered plant diversity. Pristine FRV communities are associated with unmodified channels with lower nutrient status (outside of naturally eutrophic systems) and include bryophyte rich boulder cascade zones and alluvial/ riparian woodland rivers (NPWS 2013).

Floating river vegetation by its nature can alter flow patterns and encourage localised sediment deposition, on the downstream side of the stand (similar to a boulder instream) and provides shelter for invertebrates and fish. In particular, the larvae of the blackfly *Simulium* spp. can occur in extremely high densities on the *Ranunculus* fronds and provide an important food resource for young salmonids. Equally, when non-compacted, the sand tailing at the end of *Ranunculus* beds provides burrowing for lamprey ammocoetes. Fish shelter under the *Ranunculus* beds, which are especially important in large rivers such as the Lee where shading in open stretches may be unavailable, meaning FRV provides the only instream structure for fish to rest under. Different aquatic plants support different invertebrate communities and as such an increase overall aquatic diversity in riverine systems, can result from the presence of a diverse macrophyte community. The proliferation of pondweeds however can provide spawning substrata and refugia for invasive Roach *Rutilus rutilus*. Conversely in this respect macrophyte stands can be unfavourable when unnatural proliferation in slow moving reaches of river as a result of riverine modification causes an indirect proliferation of an invasive species such as roach.

2. Methods

Study Site

The River Lee (EPA code: IE_SW_19_1663) is located in hydrometric area 19 and within the South Western river basin district (SWRBD). The Lee, which drains an area of 1253km^2, is underlain by a mixed geology of

Devonian old red sandstones and Dination mudstones and sandstones, with occasional, highly localised strikes of Tournasion limestone (Geological Survey of Ireland). The Lower River Lee between Innishcarra Dam and Cork City is a lowland depositing watercourse (FW2; Fossit, 2000). It may be considered a 'C type' channel in its lower reaches (Rosgen & Silvey, 1996). C type channels are meandering in character, their banks low enough to provide regular flooding and are excellent nursery and spawning rivers for salmonid species. They can also be excellent channels for *Ranunculus spp.* vegetation given ample broken flows, good bedding materials and suitable depth profiles (per. obs.). According to the EPA the biological water quality on the River Lee achieved Q4, 'good status' at Leemount Bridge (on the R618 road) during 2011, which indicates it is meeting the requirements of the Water Framework Directive (2000/60/EEC). The good quality water and natural profile of the Lower River Lee account for it being an excellent habitat and study area for *Ranunculus spp.* vegetation. As Floating River Vegetation is predominantly a freshwater habitat, the survey's lower extent was the brackish water tidal areas where the community can no longer persist given the unsuitable conditions. The site surveys were undertaken during June 2015 on the River Lee between Innishcarra Dam and the City centre.

Floating River Vegetation Evaluation

The channel of the River Lee was surveyed by bank between the 20th and 30th of June 2015. Areas containing stands of *Ranunculus* vegetation provided excellent visual markers of the presence of FRV as *Ranunculus* vegetation is a major component of FRV communities. Based on the results of the preliminary surveys carried out during late summer 2014, zones of low, medium and high FRV cover were surveyed using three replicates of each generic cover category.

A string quadrat was set up covering a 10m by 10m zone. It was then surveyed by standing at the upstream end (to avoid glare) and the percentage cover was estimated for each of the aquatic macrophytes contained within the quadrat. Following the first estimation the surveyor walked the four corners and estimated the cover of each quadrat (i.e. 2.5m by 2.5m zone) as the average cover from each of the four quadrats provided a more accurate estimate. Three replicates within each zone (low, medium & high cover FRV) were recorded to establish mean percentage cover for each macrophyte plant recorded, reducing the overall standard error.

Where *Ranunculus* spp. was absent, the other species comprising the FRV composition within the River Lee (i.e. *Myriophyllum spp., Callitriche spp., Potamogeton spp.* and *Fontinalis antipyretica)* were generally present at very low levels.

The deep sections (>2m) of slower moving riverine habitat were surveyed by scuba diving to assess FRV diversity and distribution. Typically these areas had low cover of *Ranunculus* and contained pondweeds, starworts, millfoils and mosses. The FRV communities were summarised by percentage cover for visual mapping representation of habitat distribution using Quantum GIS version 2.10. Five categories were chosen, 0-4%, 5-10%, 11-20%, 21-30% & 31-60% and 61%+ (see table 2.1 below).

Table 2.1 – Categories of % Cover for *Ranunculus* Vegetation

Category	Percentage Cover
Very Low Cover	0-4%
Low Cover	5-10%
Moderate Cover	11-20%
High Cover	21-30%
Very High Cover	31-60%
Extreme Cover	61% +

Measurement of habitat variables

Once the main channel of the lower River Lee had been assessed for the distribution and diversity of FRV vegetation, key habitat variables were measured. These included flow rate, nutrient levels (N & P), suspended solids, river depth, pH and substrate composition.

These variables were measured in each of the three FRV zone classes (low, medium and high cover). This would facilitate a preliminary identification of the key characteristics driving the presence or absence of FRV habitat.

3. Results

Characterisation of Floating River Vegetation

FRV habitat was widely distributed throughout the River Lee from Innishcarra Dam to Cork City. The habitat was dominated by *Ranunculus* vegetation which broadly defined the extent of the FRV habitat. Typically *Ranunculus* vegetation that comprised solely *Ranunculus penicillatus* sp. formed stands which covered large areas of channel in the shallower and faster flowing sections of river. The percentage cover of *Ranunculus* vegetation was notably higher during the optimum growth period of June 2015 than when recorded during the preliminary surveys of September 2014 (see Figure 3.1).

Ranunulus penicillatus sp. was only found present very locally in water depths in excess of 1.5m and had its highest percentage cover in shallower areas <1m depth. These areas were classic riffle and glide sections of river channel which contained very clear water, thus permitting growth. The *Ranunculus* zones were typically dominated by cobbles and lesser quantities of gravel substrata. In these *Ranunculus* dominated zones macrophyte diversity was typically low, with only a very low percentage cover of *Berula erecta* also found present (typically <1% cover). In addition to *Ranunculus penicillatus* the moss species *Fontanalis antipyretica* and *Hygroamblystegium tenax* were present locally on cobbles. The high cover *Ranunculus* zones contained between 31-61%+ cover of *Ranunculus* vegetation and are marked as red or purple on Figures (3.2 & 3.3). These areas included but were not limited to the following areas; downstream of Iniscarra Dam, 'Poulavone', the 'Anglers Rest', the 'Doctors Stretch', 'Woods Farm' (Carrigrohane) and in the city suburbs at the 'Kingsley Hotel' (south Channel).

Aquatic plant diversity was typically higher in slower areas of channel which had, in parallel, very low percentage cover of *Ranunculus*. These areas were slower flowing and in general had deeper channel depths and higher turbidity. In these areas with 0-5% or 5-10% cover of FRV (e.g. Innishcarra Graveyard, Ballincollig Gunpowder Mills & Lee Fields) plant species included pond weeds (*Potamogeton gramineus & Potamogeton natans*) and starworts (*Callitriche stagnalis & Callitriche obtusangula*) in addition to localised Bur reed (*Sparganium emersum*) and Canadian pondweed (*Elodea Canadensis*). The slow flowing water in these

areas also facilitated the proliferation of the invasive species Nutall's Pondweed (*Elodea nuttallii*; see Table 3.1 for macrophyte photographic record). The deeper slow flowing areas were either naturally deep scour pools (e.g. Innishcarra Graveyard, Hell Hole & Castle Hole) or in the case of the Gunpowder Mills and Lee Fields as a result of weir construction. At the two weir sites the water was artificially slowed down upstream of the weirs and thus increased the depth, turbidity and rates of sediment deposition. Light for macrophyte plants was also lower in these slow flowing areas and caused a proliferation of *Cladophora* blanket weed in the open water in the absence of competition from rooted macrophytes. *Cladophora* covered up to 22% of the substrate in June with higher estimates recorded during the preliminary surveys in September 2014. Often, Great Pond snail *Lymnaea peregra* formed abundances of over 100 individuals per m^2 where they grazed on the mats of *Cladophora* in the slow moving reaches of channel (e.g. Castle Hole, Ballincollig Weir & County Hall Weir).

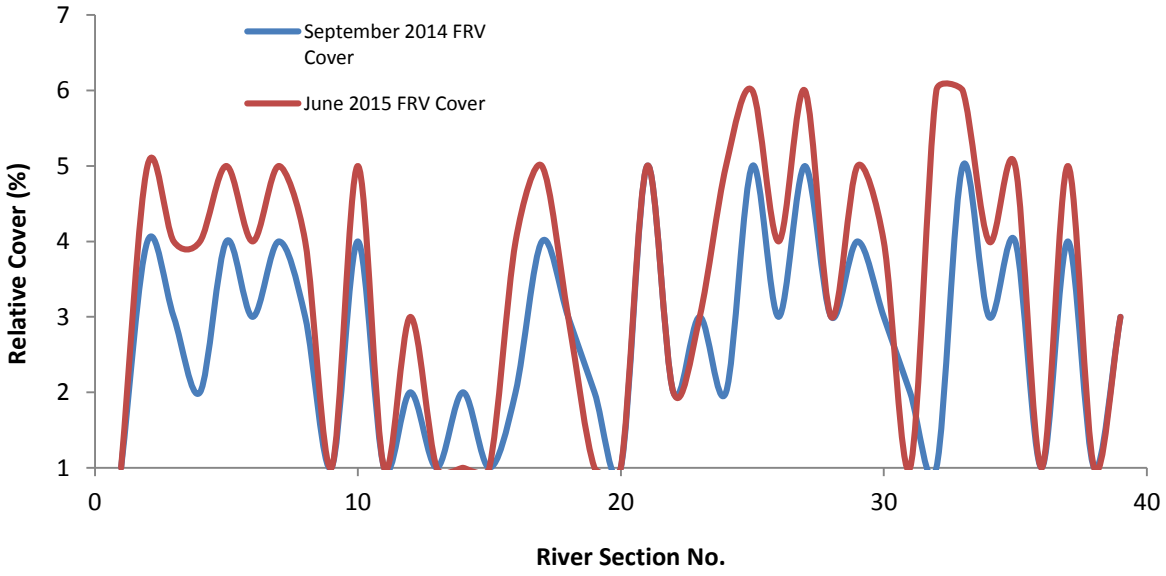


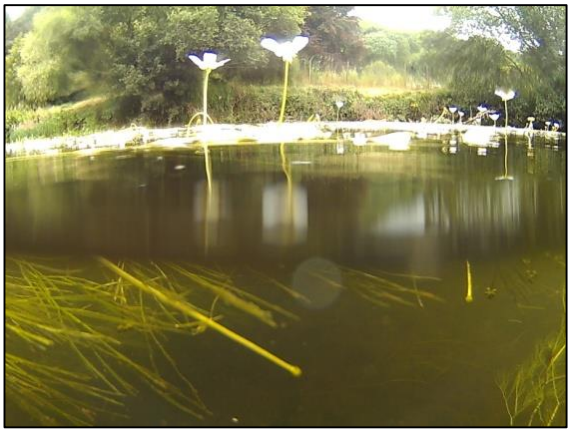
Figure 3.1 – FRV Cover during September 2014 and June 2015 surveys

Physical Variables & Floating River Vegetation

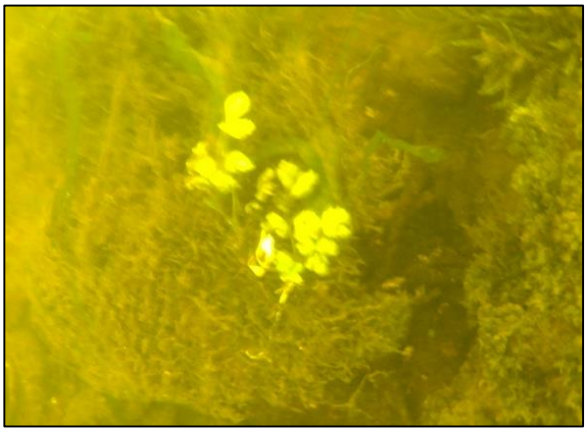
Following the mapping of the areas of importance for Floating River Vegetation within the Lower River Lee, selected areas were revisited to examine relationships between the physical and chemical properties of the watercourse and the presence of FRV communities (see Table 3.2 below). Surface flow rate, pH, nutrients (N & ortho-P), channel depth, and relative FRV cover were measured. These factors were not only measured in areas with very high percentage cover of FRV vegetation (i.e. areas with 30-70%) but also in areas with medium cover (10-20%) and very low cover (0-10%) to establish what variables were determining the presence or absence of FRV communities. As expected there was a strong positive correlation between flow rate and *Ranunculus* cover (R=0.906 see Table 3.4 Pearson's correlation) and a negative correlation between depth and *Ranunculus* cover (R=-0.862).

Myriphyllum spicatum

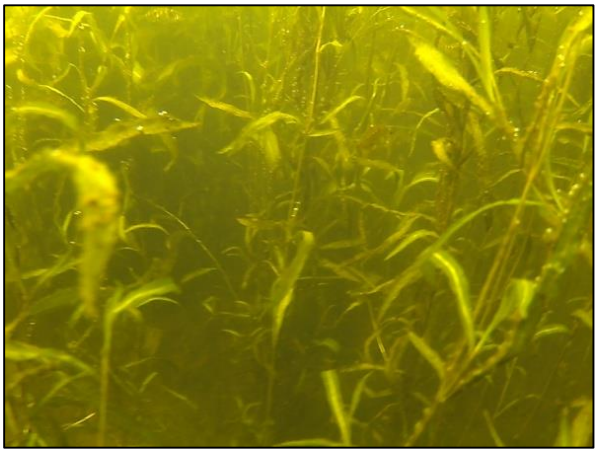
Fontanalis antipyretica moss beds



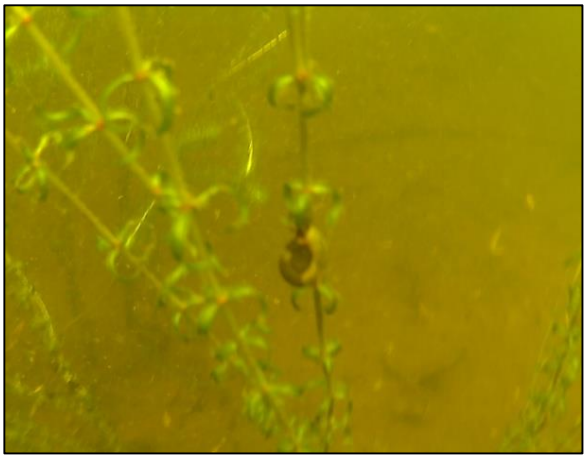
Ranunculus penicillatus var. penicillatus



Berula erecta (submerged form)

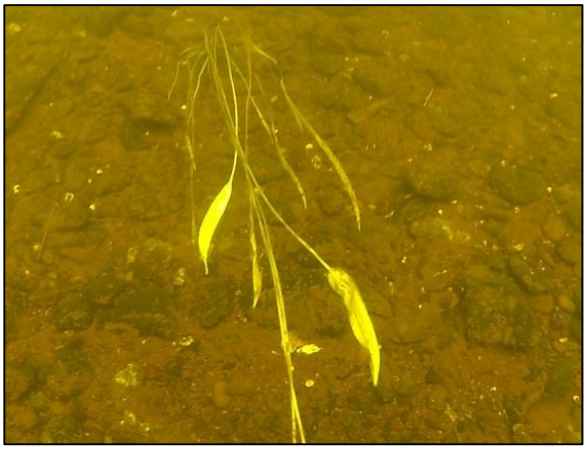


Potamogeton Crispus

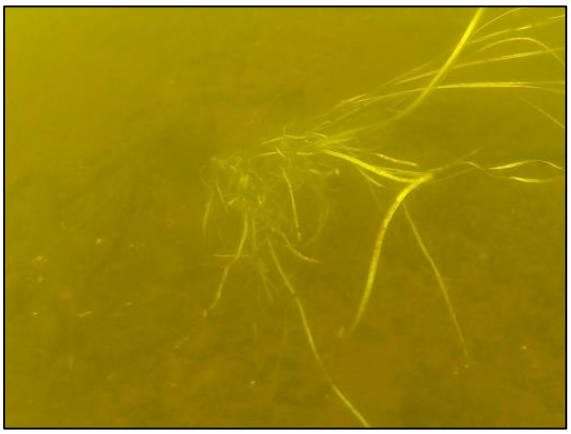


Sparagbium emersum

Potamogeton natans



Potamogeton grammineus



Sparganium emersum

Table 3.2: – Floating River Vegetation (Physcial Habitat Variables at Low, Medium & High Cover Ranunculus Zones – Lower River Lee)

FRV Cover	**Site**	**FRV % Cover**	**Alkalinity**	**pH**	**S**uspended Solids (mg/l)	Ortho-P (mg/l)	Nitrate (mg/l)	**Substrate composition**	**Macrophytes** (mean % cover of 3 quadrats)	**Liverworts** (mean % cover of 3 quadrats)	**Mosses** (mean % cover 3 quadrats)	**FRV** aquatic plant/ liverwort/ moss diversity (n)
Low Cover of Floating River Vegetation	Lee Fields (u/s weir)	0-10%	50	8.47	1.5	0.016	0.165	Boulder 5% Cobble 50% Medium Gravel 20% Fine gravel 5% Sand 5% Silt 15%	*Elodea canadensis* 0.5% *Elodea nutalli* 3% *Potamogeton natans* 1% *Myriophyllum spicatum* 1% *Ranunculus penicillatus* 2.5% *Cladophora sp.* 19% *Callitriche stagnalis* 0.5%	0%	0%	5
	Ballincollig Gunpowder Mills (u/s Weir)	0-10%		8.52	3.5	0.011	0.120	Boulder 15% Cobble 50% Medium Gravel 20% Fine gravel 10% Sand 10%	*Berula erecta* 0.5% *Ranunculus penicillatus* 1% *Potamogeton gramineus* 0.5% *Callitriche obtusangula* 1% *Myriophyllum spicatum* 0.5% Cladophora sp. 22%	0%	0%	3
	Hell hole	0-10%		8.51	2.0	0.012	0.160	Boulder 10% Cobble 40% Medium Gravel 30% Fine gravel 5% Sand 5% Silt 10%	*Berula erecta* 0.5% *Ranunculus penicillatus* 1% *Cladophora sp.* 18%	0%	*Fontanalis antipyretica* 0.5%	2
Medium Cover of Floating River Vegetation	Curraghbeg (d/s Innishcarra Dam)	10-20%	40	8.02	4.0	0.011	0.109	Boulder 10% Cobble 40% Medium Gravel 20% Sand (coarse) 30%	*Berula erecta* 0.5% *Ranunculus penicillatus* 19% *Cladophora* sp. 5%	0%	*Fontanalis antipyretica* 1%	2
	Grotto	10-20%	46	8.22	5.1	0.018	0.149	Boulder 0% Cobble 50% Coarse Gravel 30% Medium Gravel 10%	*Ranuncuilus penicillatus* 18% *Cladophora* sp. 18% *Potamogeton pusillus* 0.1%	0%	*Fontanlis antipyretica* 5%	2

								Fine Gravel 5% Sand (coarse) 5%				
	Anglers Rest u/s	10-20%	44	8.31	4.2	0.016	0.146	Boulder 0% Cobble 60% Coarse Gravel 20% Medium Gravel 10% Fine Gravel 5% Sand (coarse) 5%	*Ranuncuilus penicillatus* 15% *Berula erecta* 0.5% *Sparganium emersum* 0.1% *Cladophora* sp. 0.5%	0%	*Fontanlis antipyretica* 0.5%	1
High Cover of Floating River Vegetation	Poulavone	30-70%	41	8.42	2.1	0.015	0.144	Cobble 30%; Coarse Gravel 30%; Medium Gravel 20%; Fine gravel 15%; Sand 5%	*Ranunculus penicillatus* 50%; *Berula erecta* 0.5%; *Cladophora sp.* - 9%	*Porella pinnnata* – 0.5%	*Fontanalis antipyretica* 0.5%; *H.tenax* – 0.5%	3
	Angler's Rest (downstream)	30-70%	42	8.5	1.8	0.016	0.167	Cobble 50%; Coarse Gravel 25%; Medium Gravel 15%; Fine gravel 5%; Sand 5%	*Ranunculus penicillatus* 62%; *Berula erecta* 1%; *Cladophora sp.* - 7%	*Porella cordaena* (above waterline) & *Preissa quadrata*	*Fontanalis antipyretica* 2%; *H.tenax* - 1%	3
	Kingsley Hotel	30-70%	51	8.4	1.8	0.018	0.165	Cobble 30% Medium Gravel 40% Fine gravel 20% Sand 5% Silt 5%	*Ranunculus penicillatus* 70%; *Berula erecta* 0.5%; *Cladophora sp.* - 1%	*Marchantia polymorpha* 1%; *Chiloscyphus polyanthus* 0.5%	*Fontanalis antipyretica* 1.5%; *H.tenax* – 1.5%	3

Table 3.3 – Surface flow rates at low, medium and high cover FRV zones

		Point 1 (2m from bank)		Point 2 (4 m from Bank)		Point 3 (mid channel)		Point 4 (4m opposite bank)		Point 5 (2m from opposite bank)			
Cover Category	**Site**	**Flow (ms-1)**	**Depth**	**Flow (ms-1)**	**Depth**	**Flow (ms-1)**	**Depth (m)**	**Flow (ms-1)**	**Depth (m)**	**Flow (ms-1)**	**Depth (m)**	**Mean Flow**	**Mean Depth**
Low Cover of Floating River Vegetation	Lee Fields (u/s weir)	0.15	**1.6**	0.18	**2.3**	0.19	**2.0**	0.18	**2.4**	0.09	**2.0**	**0.16**	**2.06**
	Ballincollig Gunpowder Mills (u/s Weir)	0.19	**1.5**	0.2	**2.2**	0.19	**2.1**	0.1	**1.8**	0.09	**0.9**	**0.15**	**1.70**
	Hell Hole	0.03	**1.0**	0.04	**2.2**	0.21	**3.1**	0.20	**2.7**	0.10	**1.5**	**0.12**	**2.1**
Medium Cover of Floating River Vegetation	Curraghbeg (d/s Innishcarra Dam)	0.38	**0.49**	0.33	**1.2**	0.19	**0.49**	0.24	**0.55**	0.29	**0.7**	**0.29**	**0.69**
	Grotto	0.04	**0.56**	0.09	**0.7**	0.23	**1.2**	0.20	**1.35**	0.15	**0.8**	**0.14**	**0.91**
	Anglers Rest	0.06	**0.70**	0.33	**1.30**	0.24	**1.10**	0.24	**1.20**	0.11	**1.0**	**0.19**	**1.06**
High Cover of Floating River Vegetation	Doctors Stretch	0.18	**0.15**	0.37	**0.15**	0.36	**0.16**	0.37	**0.3**	0.36	**0.16**	**0.328**	**0.184**
	Kingsley Hotel	0.28	**0.30**	0.37	**0.6**	0.39	**0.79**	0.42	**0.71**	0.39	**0.58**	**0.370**	**0.59**
	Poulavone	0.23	**0.15**	0.35	**0.13**	0.32	**0.24**	0.42	**0.44**	0.36	**0.21**	**0.336**	**0.23**

Table 3.4 – Pearson's Correlation table for measured variables across low, medium & high cover FRV zones

	pH	*Suspended Solids (mg/l)*	*Ortho-P (mg/l)*	*Nitrate (mg/l)*	*Depth (m)*	*Flow (ms^{-1})*	*Ranunculus Cover*	*FRV diversity (n)*
pH	1.000							
Suspended Solids (mg/l)	-0.675	1.000						
Ortho-P (mg/l)	0.054	-0.069	1.000					
Nitrate (mg/l)	0.569	-0.602	0.696	1.000				
Depth (m)	0.372	-0.071	-0.405	0.052	1.000			
Flow (ms^{-1})	-0.100	-0.373	0.230	0.093	**-0.840**	1.000		
Ranunculus Cover	0.046	-0.358	0.513	0.352	**-0.862**	**0.906**	1.000	
FRV diversity (n)	0.510	-0.692	0.108	0.302	0.091	0.228	0.193	1.000

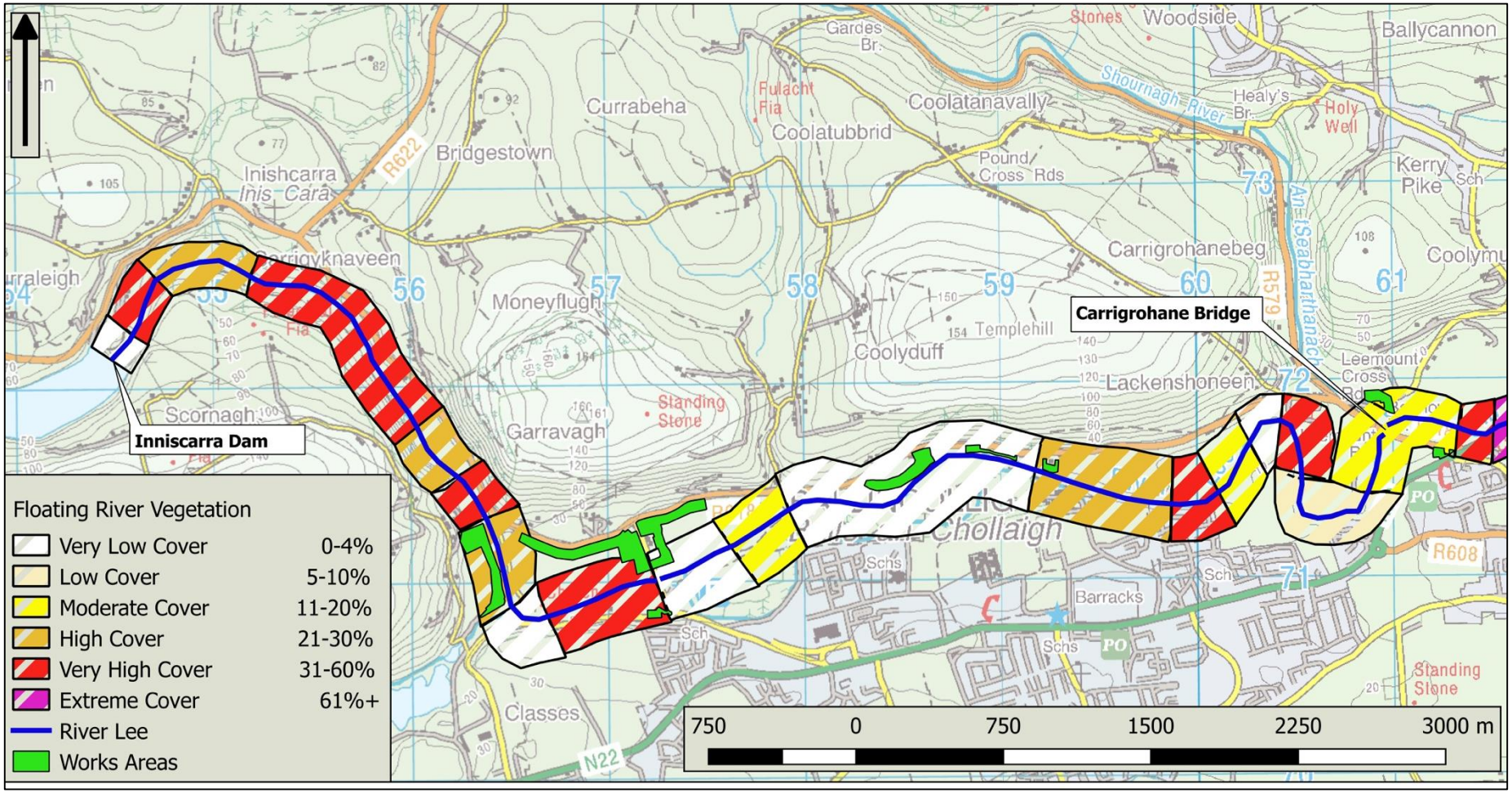


Figure 3.1 – Floating River Vegetation Distribution Map (June 2015) in the Lower RivLee (Innishcarra Dam to Leemount Bridge)

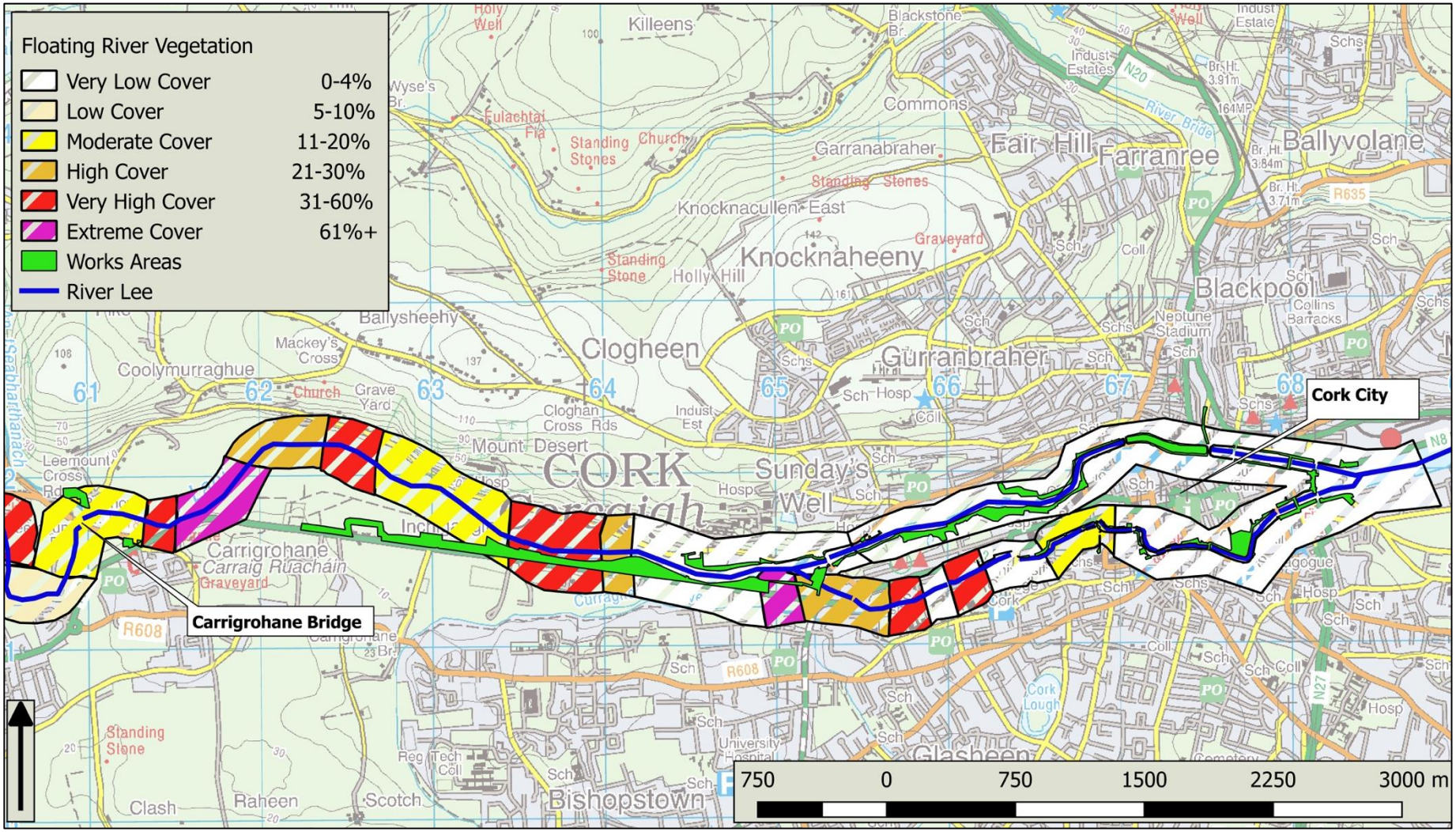


Figure 3.2 – Floating River Vegetation Map (June 2015) in the Lower River Lee (Leemount Bridge to Port of Cork)

Projected Flow Flates

The design projections for flow rates have been calculated by the engineering team based on a five year return period or a 20% annual exceedance probability (AEP) for the baseline (existing) and design flows. The average AEP calculations for the baseline and the design calculations were 1.372ms^{-1} and 1.718ms^{-1} indicating an average AEP increase of 0.345ms^{-1} across the FRV zones on the Lower River Lee. This approximates to 20% increase in the flow rates from the baseline of the 5 year return period AEP. The baseline and design velocities of the 5 year return period or 20% AEP are illustrated as blue and red lines on Figure 3.3 below respectively.

When viewing the graph below there does appear to be a loose trend whereby increases in flow rate follow increases in FRV percentage cover. However the regression of this relationship was not significant ($r=0.032$, $p=0.304$, $d.f.=1$), i.e. no significant correlation between areas with a projected increase in flow rate and increased cover of FRV.

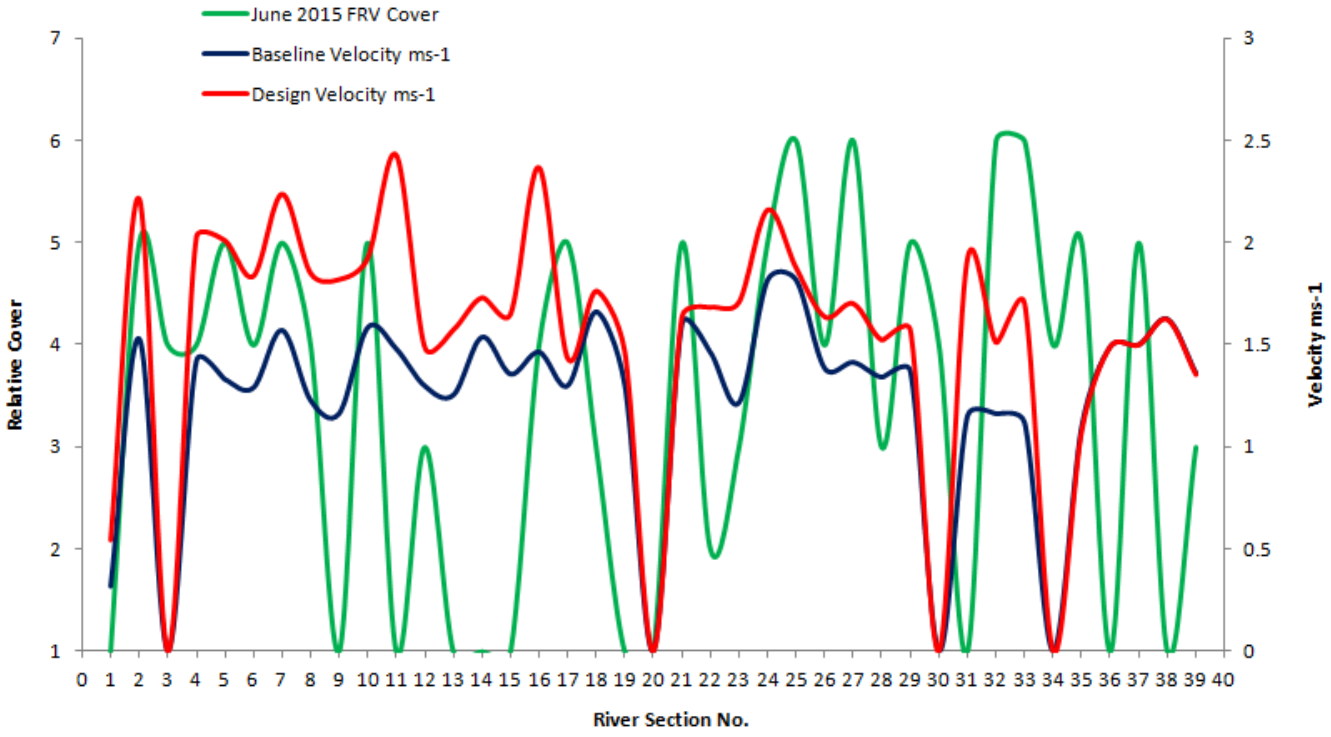


Figure 3.3 – Baseline & Design AEP versus relative cover of FRV longitudinally on the Lower River Lee

4. Discussion

The distribution of floating river vegetation (FRV) under the broad definition of the habitat i.e. that encompassing representatives of the taxa (*Ranunculus, Myriophyllum, Potamogeton* and aquatic mosses) was widespread in the Lower River Lee. The better quality habitat could be considered as that which had the highest percentage cover of *Ranunculus* or where a high diversity of plants within the habitat collective occurred.

Interestingly diversity of the instream macrophytes can be expected to be characteristically low in the natural fast riffle and glide areas of channel as these have the highest flow rates. Patterns of erosion and deposition are relatively constant in these areas as the river bed has not been modified by arterial drainage. FRV zones with medium to high cover of *Ranunculus* had combinations of riffle, glide and localised pool habitat, were fast flowing, shallow, and had clear water and little or no sedimentation. Indeed, *Ranunculus* cover was positively correlated with flow rate and negatively correlated with depth (see Table 3.4 results section). *Ranunculus* in fast flowing areas of channel with stable riverbed substrata were able to form dense stands in the absence of excessive shading and competition from other macrophytes that favour finer substrata and slower flowing water. *Ranunculus* was also found alongside *Fontanalis antipyretica* and *Hygroamblystegium tenax* moss species. *Fontalis antipyretica* favoured the surface of cobbles while *Hygroamblystegium tenax* was found on the downstream side of cobbles typically covering a lower surface area. Where cobbles were absent moss species were also absent as the channel bed would consequentially be less stable and thus unsuitable for mosses.

In contrast to characteristic *Ranunculus* zones, which are considered the best examples of FRV habitat in the River Lee given the overall low diversity of truly aquatic macrophytes within the habitat complex, modified areas of channel with slower, deeper and more turbid water were considered poorer examples of the habitat. These areas while having a more diverse assemblage of aquatic plants had a low percentage cover of macrophytic vegetation that included some species that fell within the FRV categories (i.e. *Potamogeton* spp., *Callitriche* spp. and *Myriophyllim* spp.) but which also contained the invasive pondweed species *Elodea nuttallii* and the closely related non-native species *Elodea canadensis*. While the communities of plants may be considered marginally more diverse, the quality of the habitats was typically poor. This was considered as the slow moving sections of channel were as a result of impoundments, notably weir structures. Weir structures cause water to slow down behind the head of the weir and also artificially deepen the channel at the upstream side. Consequentially sedimentation and settling out of nutrients encouraged the proliferation of a *Potamogeton-Myriophyllum-Callitriche* community and of invasive *Elodea nutalii*. As these areas were largely restricted upstream of weir sites, or occurred more locally in small bays, the area of cover was small.

The wider expanse of these modified areas of habitats were not representive of Potamogeton-Myriophyllum-Callitriche communities and rather, the wider substrata contained a very high percentage cover of *Cladophora spp.* blanket algae (typically over 20% cover). Extensive filamentous and epiphytic (diatomaceous) algae are considered indicative of unfavourable condition (NPWS, 2013), as such the areas with low cover of *Ranunculus* that were defined by deep, slow flowing water and dominated by *Cladophora* (i.e. 0-5% & 5-10% FRV classes) on Figures 3.1 & 3.2 of the results section.

Threats to Floating River Vegetation

On the River Lee during periods of low rainfall, the river flows are significantly reduced which cause the proliferation of algae in the slower deeper areas of river channel. The presence of gross cover of algae (that incidentally increases % cover over the course of the summer peaking in August-September) indicates that eutrophication is a threat to FRV communities in the Lower River Lee. Sedimentation and eutrophication

of the Lower River Lee may locally shift a *Ranunculus*-dominated community to that of an epiphytic algae community as turbidity increases. Indeed deeper areas of channel with poor light penetration, while still having moderate flows of water had very low cover of *Ranunculus*.

Changes in the hydrography (i.e. natural flow pattern) of rivers can reduce retention times and increase levels of scouring, suspended solids loadings and even change channel profile (Haslam, 1997). Proposals on the Lower River Lee to alleviate flooding may increase flow rates during peak rainfall events. Should the rates of flow increase during intense rainfall events coupled with structural modifications to the channel (i.e. retaining walls etc.), erosional patterns may shift the bed structure and thus impact on the ability of *Ranunculus* to gain footing in the channel (worse case scenario). Deposition of the transported material downstream can mobilise sediment bound nutrients to slower flowing areas of channel and may encourage the proliferation of non native and invasive plants such as Nuttall's Pondweed. Furthermore the presence of invasive riparian plants such as Himalayan Balsam (*Impatiens glandulifera*), in the presence of a changing hydrography (i.e. higher flow rates) may cause further sediment deposition as Himalayan Balsam dies back in winter and river banks are eroded as a result.

Proposals

Given that the Lower River Lee has never been dredged and is largely unaltered apart from localised retaining walls and weir structures, the river bed is largely comprised of cobble, coarse gravels and sand. This it appears has created a habitat that is optimal for the growth of *Ranunculus penicillatus* species coupled with swift water flows. Given the low resistance of *Ranunculus penicillatus* it is most adapted to faster spate type channels. The most important question to be answered with regards to potential impacts to the FRV community is how changes in flow rates could change the distributional pattern of *Ranunculus*? First, the critical factors that cause a plant to be uprooted by flow must be established. This depends on three critical factors; force of the pulling effect of the current on the plant, (ii) the hydraulic resistance of the plant, (iii) the anchoring strength. *Ranunculus* species require large volumes of water to grow vigorously (Westlake, 1976). In the River Lee, the floating river vegetation community is largely represented by *Ranunculus penicillatus* species, a species from within the *Ranunculus* genus that does require strong water flows for growth as has been elucidated in this study. *Ranunculus penicillatus* is a streamlined, many leaved species and as such offers low resistance to flow and thus is one of the most tolerant riverine species to river spate (resistance of 40g, see p. 47, Haslam 2006). The species also only fragments at high force and as such has a very high anchoring strength (>750g, see p. 51, Haslam 2006). *Ranunculus penicillatus* is also very tolerant to battering (force of pulling effect) placing it in the most tolerant class (see p. 55, Haslam 2006). The projected flow increases of the flow rates in terms of a 5 year return period are considered small at 0.345ms^{-1} approximating to a 20% increase during spate events from the baseline. These events would typically occur during the winter after *Ranunculus* stands have broken down. It is considered unlikely that the cover of *Ranunculus penicillatus* would be reduced given its extremely high tolerance to flow rates.

It must also be noted that increased sedimentation can overtime destabilise the root zone and reduce the area of *Ranunculus* stands. However, the consistant swift flow rates in the River Lee (because the river flow is controlled by an upstream hydro-electric dam) mean that sedimentation is unlikely with the exception of slack water areas behind artificial weirs. While at the outset one may view these areas as outside the realm of a natural riverine environment, they do however tend to support the most diverse plant assemblages on the River Lee. While the percentage cover may be low, they nonetheless corresponded to an FRV community (i.e. *Potamogeton* & *Callitriche* species). Sedimentation may increase locally in areas behind weirs including Ballincollig and County Hall and Nuttall's waterweed may increase locally in these areas during low flow periods in summer. However, Nutall's waterweed appears to establish in the shallower margins of the river in completely slack areas of channel and is largely absent at depths over 2.0m. As such the Potamogeton-

Callitriche-Myriophyllum communities that were located in water typically deeper than 2m are unlikely to change significantly as a result of potentially higher deposition (and consequentially local increases in Nutall's waterweed) behind man-made structures.

Hydromorphology (as defined by the WFD, is the physical characteristics of the shape, boundaries and content of a water body) will change naturally overtime on any river system. The projected AEP levels, equivalent 20% increase in the flow rates from the baseline of the 5 year return period AEP are not considered to alter the hydromorphological structure of the river considerably relative to the existing baseline. As such the patterns of FRV vegetation are expected to remain largely consistant with the existing in terms of changes resulting from river hydrograpgy because of the linkage with hydromprophological change. The main threat to the FRV community from hydromorphology would be river bed stability. Given that the flood relief works are not altering the riverbed of the River Lee and because the hard engineering works are localised in the upper catchment where the river is largely natural, the river has space to move naturally without destabilising the river bed. Therefore no prominant changes in the structure of FRV above the existing baseline are anticipated.

The FRV community is largely is represented by *Ranunculus penicillatus* and a lower diversity of other associated species. In summary the proposed changes in flow rates and resulting impacts to this community of aquatic vegetation are unlikely to change the community structure significantly in the Lower River Lee. It has been recommended however, that a survey after the implementation of the flood relief scheme be commissioned to examine whether any changes in the distribution of the FRV community have occurred, albeit significant changes are considered very unlikely.

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