APPENDIX 3-2

2021 TRITURUS AQUATIC AND FISHERIES ASSESSMENT OF PEATSLIDE IMPACTS ON MOURNE BEG

Aquatic & fisheries assessment of peat slide impacts on the Mourne Beg River catchment draining Meenbog wind farm, Co. Donegal

Prepared by Triturus Environmental Ltd. for McCarthy Keville O'Sullivan

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Non-technical summary

Triturus Environmental Ltd. in conjunction with McCarthy Keville O'Sullivan, the Lough's Agency and RIVUS Ltd., undertook a fisheries and aquatic habitat assessment of the Mourne Beg catchment draining Meenbog wind farm near Ballybofey, Co. Donegal. Following a significant peat-slide event that occurred at the site in November 2020, the surveys focused on the Sruhangarve (peat slide pathway) and downstream Mourne Beg River to determine impacts to fish populations, fish spawning and nursery habitat. The assessment also considered direct impacts to riverbed condition in addition to biological water quality and hydromorphology. Long-term Loughs Agency fisheries data and salmonid spawning (redd count) data was also reviewed and used to inform our assessment. A total of 18.95km of riverine channel was surveyed, both upstream and downstream of the peat impact zone, in July and October 2021.

The July 2021 site surveys found that siltation impacts (from peat) were evident throughout the length of our Mourne Beg River survey area some 8 months after the peat slide event, extending to >14km downstream of the Sruhangarve confluence. Siltation, in terms of riverbed surface cover, infiltration into riverine gravels and oxygen exchange (redox) was often severe. This resulted in significant reductions in the quality of habitat for salmonids and macro-invertebrates. Whilst siltation was evident in almost all areas of the peat impact zone (including shallow, fast-flowing reaches), the most significant volumes were present in depositional slow-moving glide and pool areas. Reductions in riverbed condition also impacted the hydromorphology of the river, mainly through the deterioration of bed condition, albeit much of the survey area retained hydromorphology equivalent to WFD good status (as would be expected for a natural upland river system).

Based on long term monitoring data (2011-2021), there was a significant restriction in the distribution of salmonid spawning areas (redds) in the first spawning season after the peat slide. This was primarily due to the (often severe) siltation of routinely used spawning areas. However, despite a considerable reduction, salmonid spawning was confirmed in several impacted areas of the Mourne Beg River in the December 2020-January 2021 period. Of note was the marked increase in spawning in the upper Mourne Beg River, upstream of the peat impact zone, in December 2020-January 2021.

Despite evident impacts, numbers of juvenile Atlantic salmon (recorded via electro-fishing) increased in 2021 compared to the previous year (before the peat slide), thus indicating successful spawning and recruitment within the system. However, the increasing numbers of juvenile salmon may also be explained by a parallel reduction in trout consequential of the peat slippage event. Juvenile brown trout numbers were noticeably reduced within the impact zone in 2021 and this is thought to be linked to a higher degree of impact due to an earlier (than salmon) spawning season that likely coincided with the peat slide event causing significant mortality.

A swift recovery in biological water quality of the impact zone was observed (as assessed by Q-sampling of macro-invertebrates). Most sites sampled on the Mourne Beg River had recovered to Q4 (good status) water quality by October 2021, having been significantly worse in December 2020 (when some sites supported an absence macro-invertebrate life due to severe siltation impacts). An increased diversity of clean water indicator species, such as mayflies and stoneflies, were recorded in

October 2021 demonstrating an improvement in biological water quality. The Sruhangarve, where peat slide impacts were most severe, was failing to meet Q4 (good status) thresholds in October 2021.

In conclusion, the Meenbog peat slide caused and continues to cause considerable impacts to the quality of aquatic habitats within the Sruhangarve and Mourne Beg River. Whilst there is evidence of considerable recovery, impacts are predicted to last long-term. Given the large volumes of peat present within the system as a result of the peat slide, the spate nature of the Sruhangarve and Mourne Beg River will likely result in medium-term resuspension and flushing of peat downstream, providing a lasting source of peat and associated impacts to fisheries and aquatic habitats. Other sources of impact to aquatic habitats and water quality, namely coniferous afforestation and agriculture, were identified during the 2021 surveys. These will continue to act in synergy with peat slide impacts and affect the Sruhangarve and Mourne Beg River (and also likely the downstream River Derg) into the future. Management measures recommended to alleviate these impacts include the installation and maintenance of riparian buffer zones and changes in land use practices and the stabilisation of peat banks on the Sruhangarve.

1. Introduction

1.1 Background

Triturus Environmental Ltd. were contracted by McCarthy Keville O'Sullivan to undertake a fisheries and aquatic assessment of impacts to the Mourne Beg River draining Meenbog wind farm near Ballybofey, Co. Donegal (**Figure 2.1**).

The survey was undertaken to establish fisheries and aquatic health of the watercourses draining Meenbog in light of a significant peat-slide event that occurred at the site in November 2020. A large volume of peat entered the Sruhangarve (EPA code: 01S26) to the eastern extent of the proposed wind farm site and mobilised downstream to the Mourne Beg River (01M01).

The current surveys would therefore focus on the Mourne Beg River downstream of the peat slide event and the Sruhangarve to assess impacts to fish populations, fisheries habitat and biological water quality. Furthermore, 0.25km of the Bunadowen River and 2.2km of the Mourne Beg River located upstream of the Mourne Beg-Sruhangarve confluence was included as upstream control areas. The survey work was led by Triturus Environmental and completed in conjunction with MKO, the Lough's Agency and RIVUS Ltd. Historical fisheries data (redd counting) and electrofishing data provided by the Lough's Agency was also used to help infer changes in the fisheries composition and to the known spawning areas downstream of the impact area. The integrated assessment would help determine the significance of impacts to the ecological and fisheries health of the Mourne Beg catchment and consider the prospects for ecological recovery with recommendations for future monitoring.

1.2 Fisheries asset of the survey area

The survey area is located within the MourneBeg_SC_010 and MourneBeg_SC_020 river sub-catchments. The uppermost reaches of the Mourne Beg River (EPA code: 01M01), near Lough Mourne, forms part of the Croaghonagh Bog SAC (000129), a site designated for blanket bog habitat. From near the Sruhangarve confluence (within the Republic of Ireland), the Mourne Beg River is located within the River Finn SAC (002301), for which Atlantic salmon (*Salmo salar*) are listed as a qualifying interest (NPWS, 2014). The Mourne Beg River, from its confluence with the Sruhangarve, also forms part of the River Foyle and Tributaries ASSI (229), which is designated for, among other species, Atlantic salmon (DAERA, 2015). In the upper catchment, the river also forms a boundary with Croagh Bog ASSI (378) (no aquatic qualifying interests).

The Mourne Beg River rises at Mourne Lough and flows, primarily through peatland areas, for approx. 26km before joining the River Derg 3.5km upstream of Castlederg, Co. Tyrone. The river is known to support Atlantic salmon and brown trout (*Salmo trutta*), in addition to minnow (*Phoxinus phoxinus*), stone loach (*Barbatula barbatula*), three-spined stickleback (*Gasterosteus aculeatus*) and pike (*Esox lucius*) (Paul Johnston Associates, 2017; Triturus data 2021; Loughs Agency data 2011-2021). It its lower reaches, the river also supports *Lampetra* sp. (Niven & McAuley, 2013). Within the wider Foyle catchment, the Mourne Beg is an important spawning river for Atlantic salmon.

The Bunadowen River (01B01), a Mourne Beg tributary, is also known to support Atlantic salmon, brown trout and European eel (Loughs Agency data, 2020-21; Paul Johnston Associates, 2017)

Since the peat slide event (November 2020), the Sruhangarve (01S26) is known to support European eel and a low density of brown trout (Loughs Agency data, 2020-21; Paul Johnston Associates, 2017).

1.3 Peat and impacts of peat slides

Peat is a type of soft soil containing at least 65% fibrous organic material or less than 35% mineral content (Salimin et al., 2010; Huat et al., 2011). Commonly found across Ireland, peatlands are formed by the accumulation of partially decayed vegetation in areas of high rainfall, that are decomposed through anoxic conditions over thousands of years (Deboucha et al*.,* 2008). Peatlands store large amounts of carbon and are considered to be the most space-effective carbon stores of all terrestrial ecosystems (Dise, 2009). Peatlands cover approximately 20% or 14,000km^2 of the Irish national land area (Connolly & Holden 2009), holding approximately 75% of national soil carbon stocks (Renou-Wilson et al., 2011). The chemical characteristics of peats include chemical composition, cation exchange capacity (CEC) and acidity (Huat et al., 2011). Peat comprises predominantly dissolved organic carbon (DOC), oxygen (O), hydrogen (H) and small amounts of nitrogen (N) with percentage ranges of 40 to 60%, 20 to 40%, 4 to 6% and 0 to 5%, respectively (Parfenova et al., 2016; Andriesse, 1988; Schelkoph & Hasset, 1983). Other nutrient components in peat include calcium, magnesium, phosphorus and potassium (Wang et al., 2015; Worrall et al., 2002).

For centuries peatlands have been subject to artificial drainage, which has been in response to agricultural demand, forestry, horticultural and energy properties of peat and alleviation of flood risk (Holden et al., 2004). However, there are several environmental problems associated with drainage of peatlands, which have implications on soil properties and water quality (Holden et al., 2006). The draining of peatlands tends to increase the leaching of nutrients into receiving waters which can show large increases in ammonium (NH_4) concentrations (Harrison et al., 2014; Sallantaus, 1995), changes to pH (acidification) (Miller et al., 1996) and a net loss of calcium (Ca), magnesium (Mg) manganese (Mn) and aluminium (Al) from drained catchments (Sallantaus, 1995). A study by Daniels et al. (2012) demonstrated that streams draining eroded upland peatlands were nitrogen saturated, with significant leaching of dissolved inorganic nitrogen (DIN), particularly ammonium. A number of processes take place within peat which affects its physical and chemical properties due to the lowering of the water table following drainage. Increases in air-filled porosity promote aerobic decomposition, enhancing the mineralization of nutrients, including the carbon-bound nitrogen and sulphur and the organically bound phosphorus (Holden et al., 2006).

Events which cause severe erosion of organic soils into receiving headwaters, such as the Meenbog peat slide in November 2020, can have profound, deleterious impacts on river ecosystems. These can lead to major shifts in biodiversity via smothering of the benthos, increased abrasive suspended loads, a reduction in water quality, modifications to river habitat and changes to functional processes which provide energy to aquatic food webs, such as primary production (Aspray et al. 2017, Kemp et al., 2011).

Colmation, also referred to as clogging, fine sediment infiltration, fine sediment deposition, ingress, infilling, intrusion of fines, siltation, and the surface-subsurface exchange of particles (Brunke, 2013; Wharton et al., 2017), is particularly damaging to riverine habitats. Impacts of sedimentation in aquatic ecosystems can manifest across multiple levels of biological organisation, from individual organisms to whole-ecosystem processes. Impacts on individuals occur via changes to oxygen concentrations (physiology), foraging efficiency and locomotion (behaviour). These alterations may lead to emigration of organisms from the degraded habitat (Aspray et al. 2017), mortality and local extinctions of sensitive species (Kemp et al., 2011; Wood & Armitage, 1997), and proliferation of sediment and nutrient-tolerant biota (Larsen & Ormerod, 2010). Increased concentrations of metals, nutrients, and dissolved organic carbon because of sedimentation (Jones et al., 2012; Bilotta & Brazier, 2008) can further stress river ecosystems (Ramchunder et al., 2012). Medium to long-term indirect impacts are evident due to changes of the physical environment (e.g., changes in sedimentology, loss of spawning sites) as well as short-term, direct (highly dynamic) impacts due to physiological stress (e.g., high turbidity for fish) or risk of abrasion (e.g., for macro-invertebrates) (Hauer et al., 2018). Large shifts in community structure can negatively impact on key ecosystem processes for a variety of groups, including benthic algae and macrophytes (Izagirre et al., 2009; Jones et al., 2014), macro-invertebrates (Extence et al., 2013; Larsen et al., 2010), and fish, especially salmonids (Greig et al., 2005, 2007). In particular, salmonid reproduction is often curtailed because of colmation or depletion of river substratum (Sternecker et al., 2013b).

2. Methodology

2.1 Selection of watercourses for assessment

To evaluate any potential fisheries and water quality-related impacts of the November 2020 Meenbog peat slide event on the Sruhangarve (EPA code: 01S26) and Mourne Beg River (01M01), a total of 18.95km of riverine channel was surveyed in July 2021 (**Table 2.1; Figure 2.1**). This included a 2.2km length of the Mourne Beg River upstream of the Sruhangarve confluence (i.e. upstream control area), in addition to the lowermost 0.25km of the Bunadowen River (01B01).

Table 2.1 Summary of RHAT and fisheries habitat survey sections, June 2021

Section no.	Watercourse	Total length	No. RHAT sections	No. Life Cycle Unit sections	ITM start	ITM stop
U1-U5	Mourne Beg River (upstream control area)	2.2km	5	25	609871, 888292	608567, 888020
B1	Bunadowen River (upstream control area)	0.25km	1	3	608091, 887605	608204, 887820
S1-S5	Sruhangarve (d/s of peat slide)	2.3km	5	25	608894, 886222	610576, 887670
M1-M29	Mourne Beg River (d/s of peat slide)	14.2km	29	145	610576, 887670	620630, 883798
	Total	**18.95km**	**40**	**197**		

2.2 Fisheries assessment data (electro-fishing)

Semi-quantitative electro-fishing data (10-minute CPUE) on fish populations collected by the Loughs Agency in the 2011 to 2021 period was analysed to determine any trends in the salmonid populations of the Mourne Beg River, Bunadowen River and Sruhangarve before and after the November 2020 peat slide event.

Furthermore, electro-fishing data for *n*=4 sites the Mourne Beg River collated by Triturus Environmental Ltd. during surveys undertaken for the aquatic baseline of the proposed Lismullyduff wind farm project in July 2021 (Triturus, 2022) was also reviewed in context of peat slide impacts.

2.3 Salmonid habitat quality (Life Cycle Unit scores)

Fisheries habitat quality for salmonids was assessed using the Life Cycle Unit method (Kennedy, 1984; O'Connor & Kennedy, 2002) to map the Mourne Beg River, Sruhangarve and Bunadowen River survey areas as nursery, spawning and holding habitat, by assigning quality scores to each type of habitat (**Table 2.2**). Those habitats with poor quality substrata, shallow depth and a poorly defined river profile receive a higher score. Higher scores in the Life Cycle Unit method of fisheries quantification are representative of poorer value, with lower numerical scores being more optimal.

Life Cycle Unit scores were evaluated for every 100m linear length of river, equating to a total of *n*=197 survey sections and covering a total channel length of 18.95km (**Table 2.2; Figure 2.1**). The quantification of salmonid habitat quality at this micro-scale ensured the most accurate baseline data was collated, thus better informing the assessment of peat slide impacts to salmonid populations.

Table 2.2 Life Cycle Unit scoring system for salmonid nursery, spawning and holding habitat value (as per Kennedy, 1984 & O'Connor & Kennedy, 2002)

Habitat quality	Habitat score	Total score (three components)
Poor	4	12
Moderate	3	9-11
Good	2	6-8
Excellent	1	3-5

2.4 Salmonid fry abundance

The abundance of Atlantic salmon fry (i.e. 0+) recorded was classified according to the systems defined by Crozier & Kennedy (1994) (Atlantic salmon) and Kennedy (unpublished) (brown trout) (**Table 2.3**). Both systems are based on the number of fry recorded per 5-minute CPUE electro-fishing (i.e. semi-quantitative). While a ten-minute CPUE was used during the current survey, the timed fish density recorded was divided by 0.5 to assign the data to the abundance categories of Crozier & Kennedy (1994).

Table 2.3 Semi-quantitative abundance categories for 0+ Atlantic salmon (Crozier & Kennedy, 1994 and brown trout (Kennedy, unpublished)

Species	Abundance category	No. fry per 5-min CPUE
Atlantic salmon	Excellent	≥25
	Good	15-24
	Fair	5-14
	Poor	1-4
	Absent	0
Brown trout	Excellent	≥18
	Good	9-17
	Moderate	4-8
	Fair	2-3
	Poor	0-1
	Absent	0

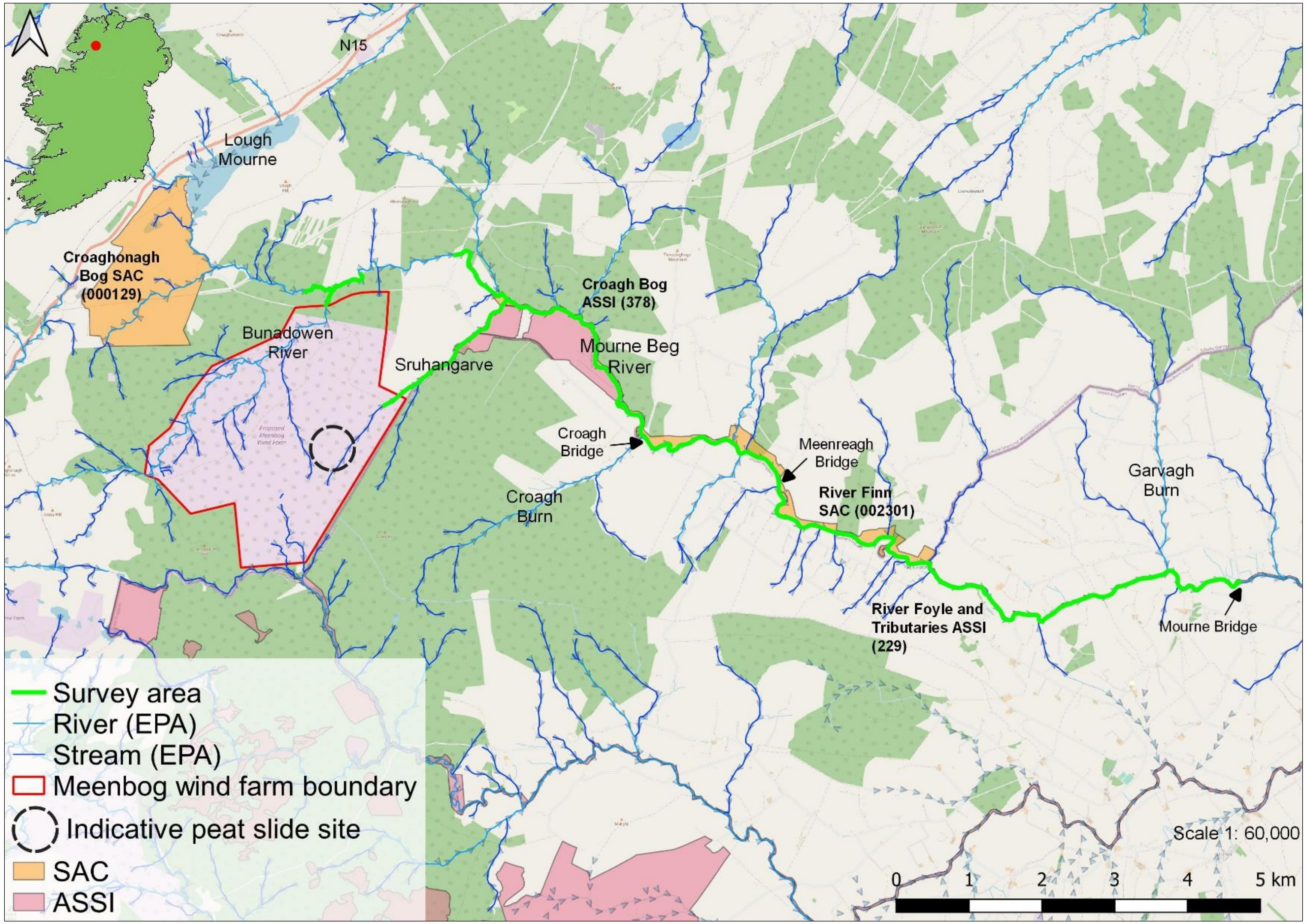

Figure 2.1 Overview of the Meenbog survey area, June 2021 (18.95km of channel)

2.5 Riverbed condition assessment (redox potential)

The condition of the river/stream bed (silt infiltration) in terms of suitability for salmonid and macro-invertebrate life stages was assessed through the measurement of redox potential. Redox potential measurements are used to determine a reading (voltage, mV) that can be used to infer the ability to obtain oxygen within the riverbed sediment (Moorkens & Killeen, 2020). Differences in redox potential between the water column and the substrate correlate with differences in oxygen levels, which serves as a proxy for assessing the condition of the riverbed in terms of suitability for spawning and early life stages of lithophilic salmonids (e.g. Atlantic salmon *Salmo salar*) and macro-invertebrates.

Three sets of three replicate redox measurements were taken for the substrata and water column, respectively, in each of the *n*=40 500m survey sections (**Figure 2.2**), in the most ostensibly suitable salmonid spawning/nursery zones (i.e. gravel/cobble areas). These areas and habitats were surveyed given the higher likelihood of impact through peat siltation/infiltration. Deeper glide and pool (holding habitat) was not surveyed. A low number of sampling sites (*n*=7) were unsuitable for redox substrata measurements due to heavily compacted/bedrock substrata (**Appendix C**). Furthermore, it was not always possible to collect three substrata replicates at each sampling site for the same reasons (e.g. sometimes only two replicates were possible). Where substrata measurements could not be collected, accompanying water column measurements were also omitted. Thus, a total of *n*=209 redox measurements were taken from the substrata and water column, respectively (*n*=418 total), from *n*=73 locations along 18.95km of riverine channel on the Mourne Beg River, Bunadowen River and Sruhangarve in July 2021.

Redox potential measurements were carried out using a WTW-modified pH instrument (Xylem Analytics, UK). This consisted of a platinum electrode and a reference electrode, silver/silver chloride (Ag/AgCl) with potassium chloride (KCl) electrolyte, connected to a pH meter. Redox potential was measured as the voltage between the platinum and reference electrodes with the measured redox potential not corrected for temperature. Redox potential readings are expressed in millivolts (mV). The redox and reference electrodes were calibrated with a standardized redox buffer solution of Eh 220mV and pH 7.0.

For water readings, both electrodes were suspended in the water column while for substrata measurements the platinum electrode was inserted to a **substrate depth of 5cm** and readings taken once the electrode readings stabilised. Where required (i.e. harder/more compacted substrata), pilot holes for the probes were bored in the sediment/substrata using a metal rod (of smaller diameter than the probes to limit water/oxygen flow during measurement).

2.6 Riverbed condition assessment (silt cover & infiltration)

Further to the assessment of redox potential, the physical coverage of silt (organic & inorganic) on riverine substrata was recorded at a total of *n*=67 locations within the 40 no. 500m survey sections on the Mourne Beg River, Bunadowen River and Sruhangarve (**Figure 2.2**). The location of these sites followed the same rationale as the redox methodology outlined in section 2.5 above, i.e. survey effort focused on shallow, faster-flowing areas suitable as salmonid spawning/nursery habitat. Following the approach for freshwater pearl mussel surveys (Moorkens & Killeen, 2020), the level of siltation as % surface cover was recorded as one of four categories, namely;

1. **No**: clean substrate surface
2. **Slight:** less than 5% cover, usually in small (sheltered) pockets
3. **Moderate**: greater than 5% but less than 25% and not forming a more or less continuous layer
4. **Severe**: greater than 25% and forming a more or less continuous layer

In addition to redox measurements (section 2.5 above), silt infiltration into the river/stream bed (**substrate depth of 5cm**) was also assessed objectively at a total of *n*=67 locations based on the presence of silt plumes (**Figure 2.2**). The degree of infiltration was scored according to the following (Moorkens & Killeen, 2020);

1. **No**: no plume
2. **Slight:** a small plume which quickly dissipates
3. **Moderate**: a small plume which is slow to dissipate
4. **Severe**: a significant plume released from the substrate

2.7 River hydromorphology (RHAT)

In order to evaluate and catalogue the degree of riverine habitat 'naturalness' on the survey watercourses in terms of overall ecology and suitability for fish species, the River Hydromorphological Assessment Technique (RHAT) was used (Murphy & Toland, 2014). The Mourne Beg River, Bunadowen River and Sruhangarve survey areas were assessed in *n*=40 discrete survey sections, along both banks (left and right, facing downstream), covering a total channel length of 18.95km (**Table 2.1**; **Figure 2.1**).

RHAT expands on the previous standards for river surveys, such as the River Habitat Survey (RHS) methodology (EA, 2003). It is assumed that natural systems support ecology better than modified systems. Hence, the RHAT method classifies river hydromorphology based on a departure from naturalness and allows for the assignment of a morphological classification directly related to Water Framework Directive (WFD) status (**Table 2.4**), i.e. high, good, moderate, poor or bad. Score calculation is based on eight semi-qualitative and quantitative hydromorphological criteria, namely:

1. Channel morphology and flow types
2. Channel vegetation
3. Substrate diversity and condition
4. Barriers to continuity
5. Bank structure and stability
6. Bank and bank top vegetation
7. Riparian land use
8. Floodplain interaction

The RHAT is designed to be a holistic visual assessment based on information from both desktop and field (walkover) studies incorporating GIS data, aerial (ortho) photography and historical data. The RHAT method was developed for WFD classification, but it also has other applications including assessing morphological pressures at a site.

Table 2.4 RHAT hydromorph scores and their corresponding Water Framework Directive (WFD) classification (Murphy & Toland, 2014)

Attribute score	Hydromorph score	WFD status
≥26	≥0.8	High status
≥19.5 to <26	≥0.7 ≤0.8	Good status
≥13 to <19.5	≥0.5 ≤0.6	Moderate status
≥6.5 to <13	≥0.3 ≤0.4	Poor status
< 6.5	≤0.2	Bad status

2.8 Biological water quality (Q-sampling)

A total of *n*=10 riverine survey sites on the Mourne Beg River (M1-M8), Bunadowen River (B1) and Sruhangarve (S1) were assessed for biological water quality through Q-sampling in October 2021 (**Figure 2.2**). Macro-invertebrate samples were converted to Q-ratings as per Toner et al. (2005). All riverine samples were taken with a standard kick sampling hand net (250mm width, 500µm mesh size) from areas of riffle/glide utilising a three-minute sample. Large cobble was also washed at each site where present and samples were elutriated and fixed in 70% ethanol for subsequent laboratory identification. Any rare invertebrate species were identified from the NPWS Red List publications for beetles (Foster et al., 2009), mayflies (Kelly-Quinn & Regan, 2012), stoneflies (Feeley et al., 2020) and other relevant taxa (i.e. Byrne et al., 2009; Nelson et al., 2011).

Table 2.5 Reference categories for EPA Q-ratings (Q1 to Q5)

Q Value	WFD Status	Pollution status	Condition
Q5 or Q4-5	High status	Unpolluted	Satisfactory
Q4	Good status	Unpolluted	Satisfactory
Q3-4	Moderate status	Slightly polluted	Unsatisfactory
Q3 or Q2-3	Poor status	Moderately polluted	Unsatisfactory
Q2, Q1-2 or Q1	Bad status	Seriously polluted	Unsatisfactory

2.9 Biosecurity

A strict biosecurity protocol following the Check-Clean-Dry approach was employed during the survey. Equipment and PPE used was disinfected with Virkon® between survey sites to prevent the transfer of pathogens and/or invasive species between survey areas. As per best practice, surveys were undertaken at sites in a downstream order (i.e. uppermost site surveyed first etc.) to prevent the upstream mobilisation of invasive propagules and pathogens.

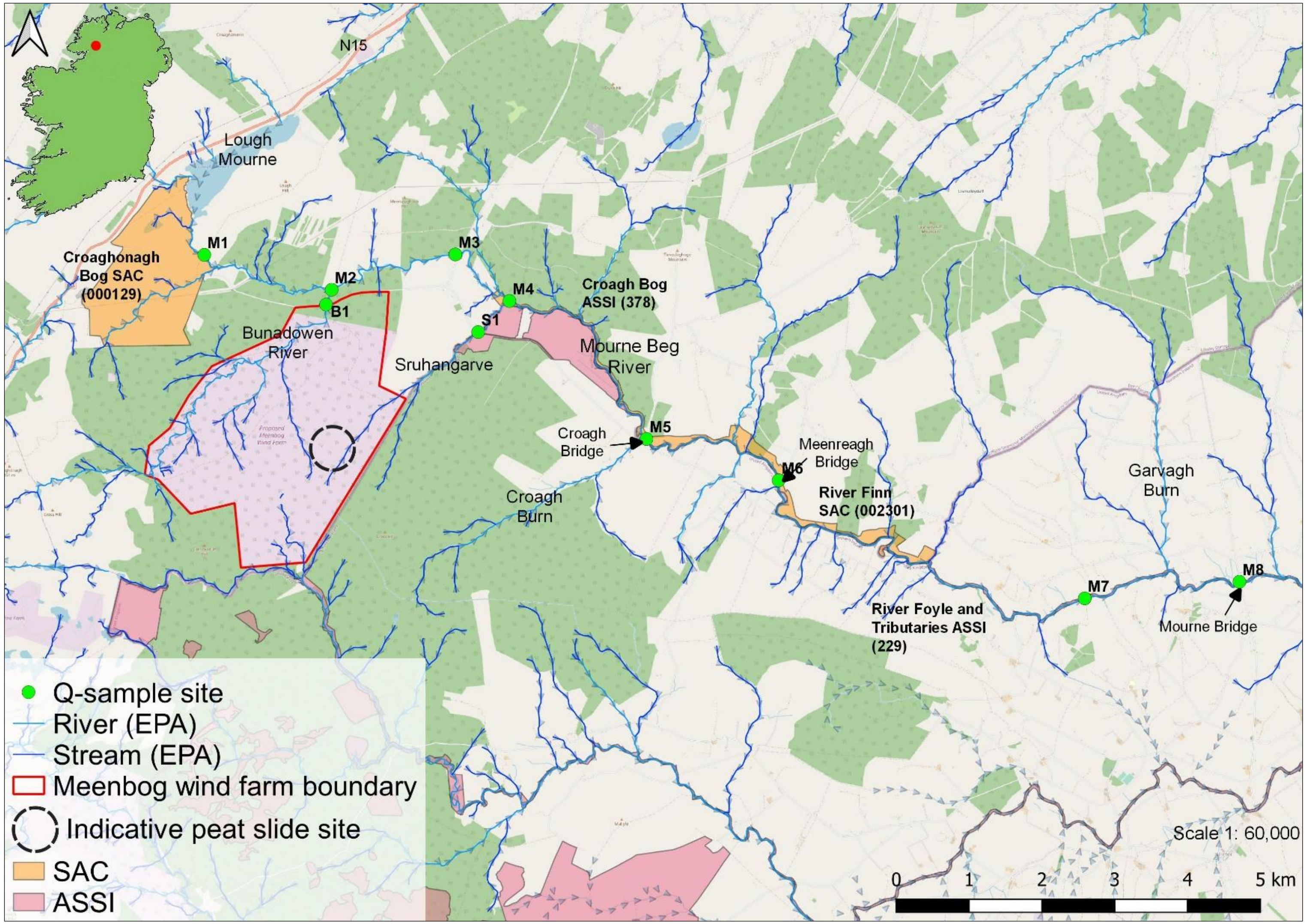

Figure 2.2 Overview of the *n*=10 biological water quality sampling locations in the vicinity of the Meenbog peat slide, October 2021

3. Results

3.1 Salmonid habitat quality (Life Cycle Unit scores)

The quality of salmonid spawning, nursery and holding habitat was mapped along 18.95km of the Mourne Beg River, including both upstream and downstream of the Sruhangarve confluence (i.e. peat impact zone). The Sruhangarve (2.3km) and Bunadowen River (0.25km) also formed part of the fisheries habitat survey area. Life Cycle Unit scores per 100m of channel are presented in **Figures 3.6, 3.7 and 3.8** below. A breakdown of the Life Cycle Unit scores for each of the *n*=197 100m survey sections is provided in **Appendix A**.

3.1.1 Upstream control area (Mourne Beg River & Bunadowen River)

The upstream control area on the Mourne Beg River (Sections U1-U5) typically supported superior salmonid habitat when compared to downstream areas, with 22 of 25 survey sections gradings as good quality overall salmonid habitat (**Appendix A**). While subject to some local variability, the good quality salmonid Life Cycle Unit Scores were attributed to the presence of good quality spawning and nursery habitat. Section U1_a (uppermost survey section) featured excellent quality spawning habitat. The Bunadowen River, which adjoined the upstream control reaches of the Mourne Beg, provided good quality salmonid habitat particularly in terms of nursery habitat (**Appendix A**).

3.1.2 Sruhangarve

Approximately half (48% & 52%) of the *n*=23 survey sections on the Sruhangarve provided moderate and good quality salmonid habitat, respectively according to the Life Cycle Unit scores. None of the survey sections provided poor quality or, conversely, excellent quality salmonid habitat according to Life Cycle Unit scores (**Appendix A**). Siltation impacts (from peat escapement) were evident throughout the survey area.

The Sruhangarve is a higher-gradient, narrow upland eroding channel that is typically of low value as a salmonid spawning habitat, ranging from poor to moderate in terms of quality. However, approximately half of survey sections (*n*=12) provided good-quality nursery habitat (**Figure 3.6**).

The Sruhangarve was of greatest value as a salmonid holding habitat. The majority of the survey sections (*n*=18) were considered as good quality holding areas (**Figure 3.8**) for brown trout only given the small size of the channel.

3.1.3 Mourne Beg River (downstream of Sruhangarve)

Approximately half (49% & 51%) of the *n*=144 survey sections on the Mourne Beg River provided moderate and good quality salmonid habitat, respectively, according to the Life Cycle Unit Scores. None of the survey sections provided poor quality salmonid habitat. Section 21_e, located downstream of Corgary Trout Farm, was the only Mourne Beg River survey section to provide excellent-quality salmonid habitat (combination of moderate spawning with excellent quality nursery and holding habitat).

Downstream of the Sruhangarve confluence, the Mourne Beg River was typically of moderate to poor quality in terms of spawning habitat. Good quality spawning areas were highly localised and present in just *n*=6 (4%) of *n*=144 survey sections (e.g. section M8 downstream of Croagh Bridge) (**Figure 3.6**). Section M9_d was the only survey section to provide excellent quality spawning habitat.

The Mourne Beg River was of greatest value as a salmonid nursery habitat. Excellent quality nursery habitat was recorded in *n*=25 (17%) of the survey sections, with good quality nursery habitat present in a total of *n*=59 (41%) of the survey sections (**Appendix A**). Only a single survey section (M8_e) provided poor quality nursery habitat. Particularly valuable nursery habitat was located between section M4_and M6_b, covering a 1.2km contiguous length of river channel. This was located ≥1.5km downstream of the Sruhangarve confluence (**Figure 3.7**).

The Mourne Beg River downstream of the Sruhangarve also provided widespread good quality or excellent quality holding habitat for adult salmonids. This was primarily due to the high frequency of deeper glide although deep pools were also present locally (e.g. on meanders). Of the survey sections, *n*=35 (25%) and *n*=36 (25%) provided excellent and good quality holding habitat, respectively. Whilst some high-quality holding areas were located in the upper reaches (e.g. near the Sruhangarve confluence), the quality of holding habitat typically improved moving downstream.

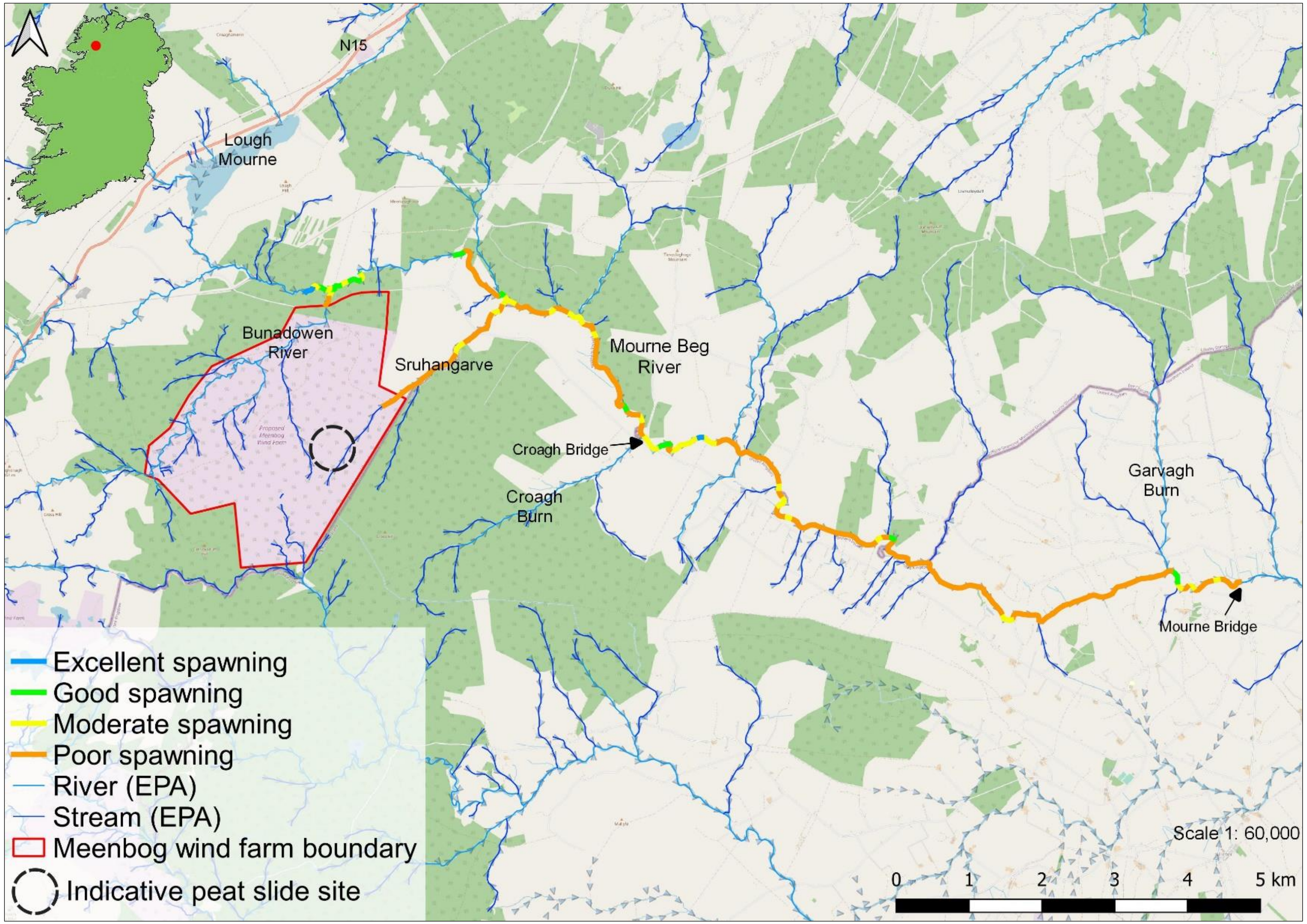

Figure 3.1 Distribution and quality of salmonid spawning habitat within the survey area, July 2021 (Life Cycle Unit scores)

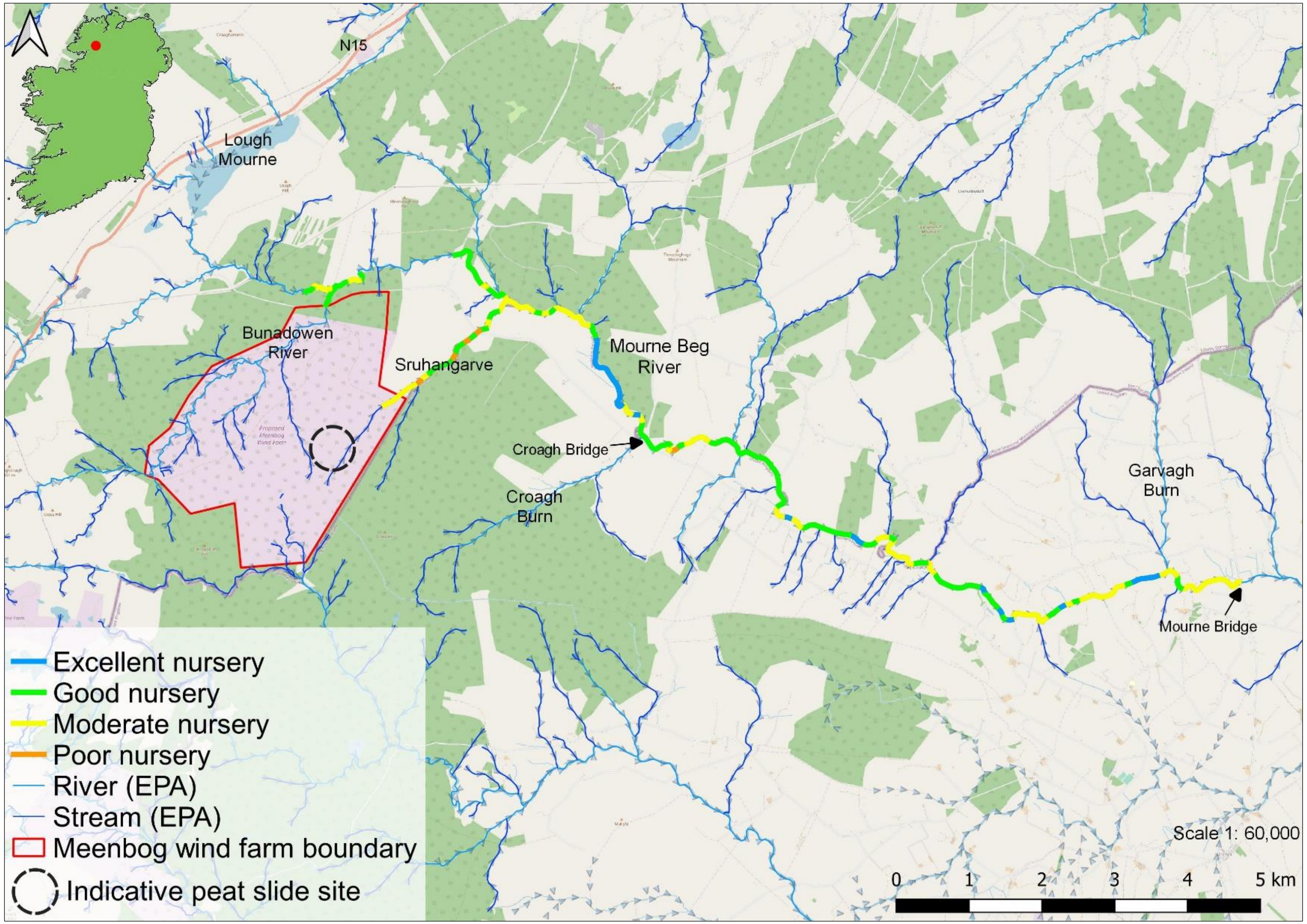

Figure 3.2 Distribution and quality of salmonid nursery habitat within the survey area, July 2021 (Life Cycle Unit scores)

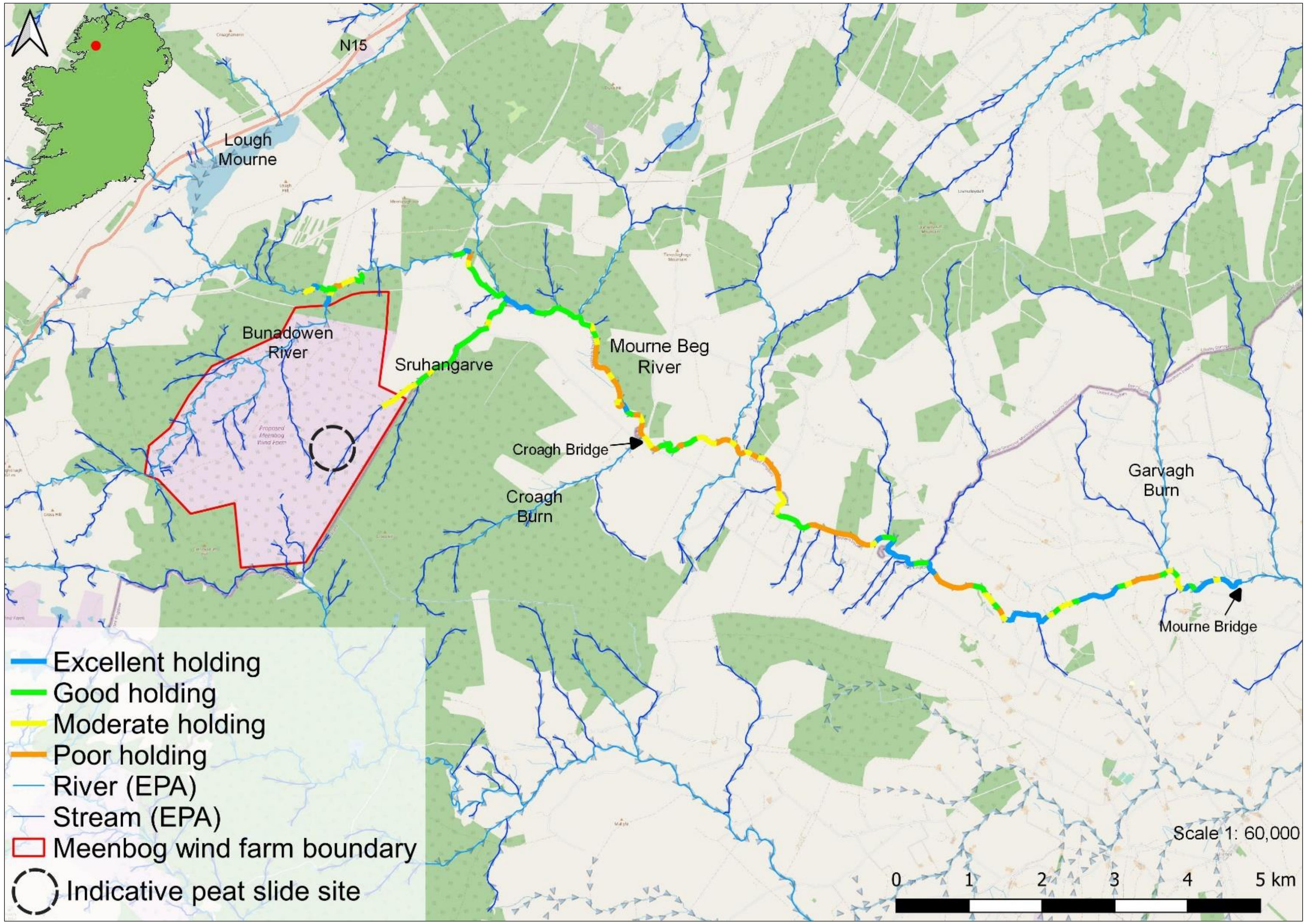

Figure 3.3 Distribution and quality of salmonid holding habitat within the survey area, July 2021 (Life Cycle Unit scores)

3.2 Riverbed condition assessment

3.2.1 Redox potential

The condition of the riverbed in terms of suitability for salmonid and macro-invertebrate life stages in the Mourne Beg River, Bunadowen River and Sruhangarve was assessed through the measurement of the percentage redox loss (between water column and substrata). A total of *n*=209 redox measurements were taken from the substrata and water column, respectively (*n*=418 total), from *n*=73 locations along 18.95km of riverine channel in July 2021.

Redox readings from the water column ranged from 184-371mV (±36.4 SD) in the Mourne Beg River and 213-383mV (±37.3 SD) in the Sruhangarve (**Appendix B**). A single site was analysed on the Bunadowen River (mean 316mV ±22.8 SD). On the Mourne Beg River, four of the five lowest mean water column readings (three replicates) were in the upstream control sections (i.e. 210, 248, 254 & 273mV), respectively (**Appendix B**). On the Sruhangarve, the lowest water column readings were located in the uppermost survey sections (i.e. nearest to the peat slide).

Substrata redox readings (5cm depth) were lower than accompanying water column readings and ranged from 108-363mV (±32.0 SD) and 89-369mV (±84.4 SD) in the Mourne Beg River and Sruhangarve, respectively. A single site was analysed on the Bunadowen River (294mV ±12.0 SD). The lowest mean substrata readings were recorded on the Sruhangarve (**Appendix B**).

Percentage redox differentials in the Mourne Beg River (sections M1 to M27) ranged from -31% to +10%, with a mode loss of -15% (**Figure 3.8; Appendix B**). With only a few exceptions (e.g. section M5), there was a general downward trend (i.e. higher % loss) moving downstream along the Mourne Beg River (**Figure 4.8**). Losses of >30% are typically considered to be reflective of anoxic conditions (Moorkens & Killeen, 2020).

The percentage redox loss was considerably lower in the upstream control sections located immediately upstream of the Sruhangarve confluence (i.e. sections U3, U4 & U5; -19% to +25% range; **Figure 3.8**).

3.2.2 Siltation & silt infiltration of riverine substrata

An assessment of siltation of riverine substrata (% cover' Moorkens & Killeen, 2020) was made at a total of *n*=60 locations on the Mourne Beg River and *n*=5 locations on the Sruhangarve. These locations were chosen based on their suitability as salmonid spawning/nursery habitat.

There was a marked difference in % surface cover of riverine substrata by peat upstream and downstream of the Sruhangarve confluence, reflecting the impact of the peat slide (**Figure 3.6; Appendix D**). Whilst some siltation was present, all *n*=10 replicates examined on the Mourne Beg River upstream of the Sruhangarve confluence featured slight siltation (≤5% cover of riverine substrata). However, the majority of downstream replicates (*n*=42 of 50) featured severe siltation (≥25% cover, range 40-90%). A total of *n*=7 replicates featured moderate levels of siltation (<25% cover). These were mostly confined to the lower survey reaches. A single replicate (M21_a) did not feature any siltation (0% cover) due to a riverbed of bedrock and fast, cascading flows. As would be expected, levels of siltation by peat were typically severe (30-100% cover) on the Sruhangarve, with only one of 5 no. replicates (S4_a) featuring moderate siltation (**Figure 3.7**).

Similar to the % cover of peat, there was a marked difference in peat infiltration of riverine substrata upstream and downstream of the Sruhangarve confluence (**Figure 3.8; Appendix D**). Whilst some siltation was present, all *n*=10 replicates examined on the Mourne Beg River upstream of the Sruhangarve confluence featured slight infiltration of sediment into riverine substrata (small plume which quickly dissipated). By contrast, the majority of downstream replicates (*n*=42 of 50) featured severe infiltration (significant plumes released upon disturbance). A total of *n*=4 and *n*=3 replicates featured slight and moderate levels of infiltration, respectively.). These were mostly confined to the lower survey reaches. These replicates were confined to the lower survey reaches (i.e. M19 onwards). A single replicate (M21_a) did not feature any infiltration of silt due to a riverbed of bedrock. As would be expected, levels of silt infiltration into riverine substrata were typically severe on the Sruhangarve, with only one of 5 no. replicates (S4_a) featuring moderate infiltration (**Figure 3.9**).

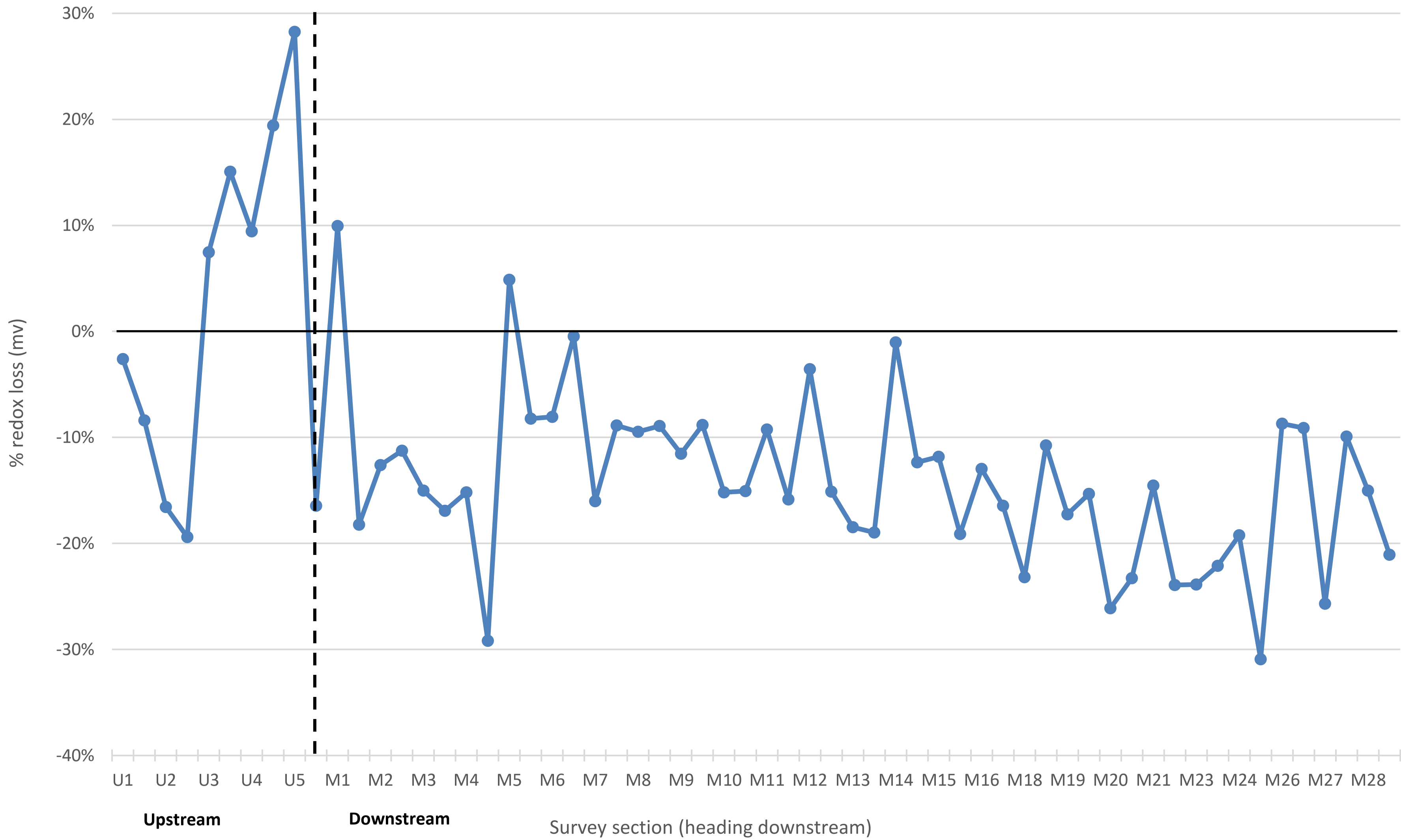

Figure 3.4 Percentage redox loss (between water column and substrata) along the Mourne Beg River, July 2021 (dashed line indicates peat slide event)

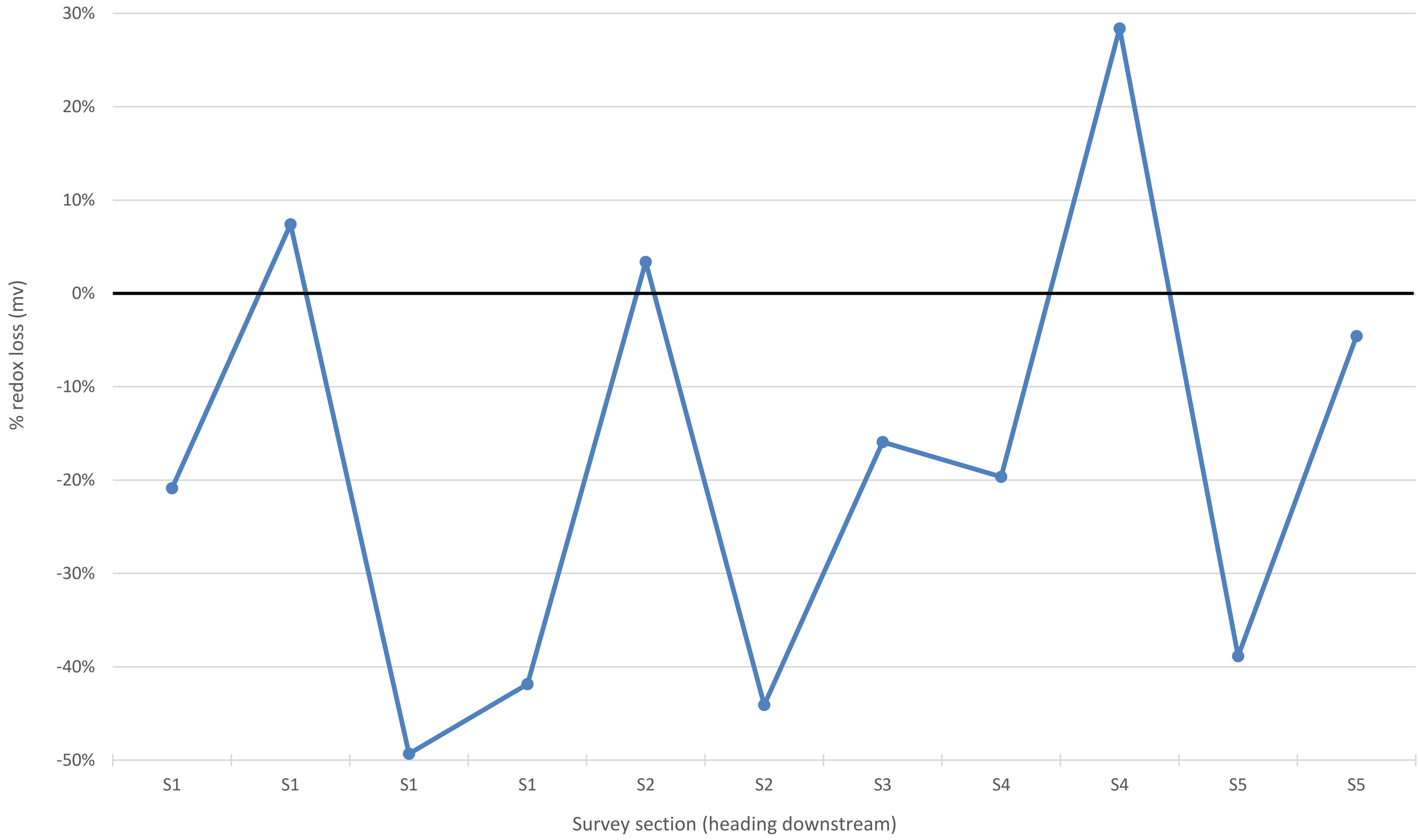

Figure 3.5 Percentage redox loss (between water column and substrata) along the Sruhangarve, July 2021

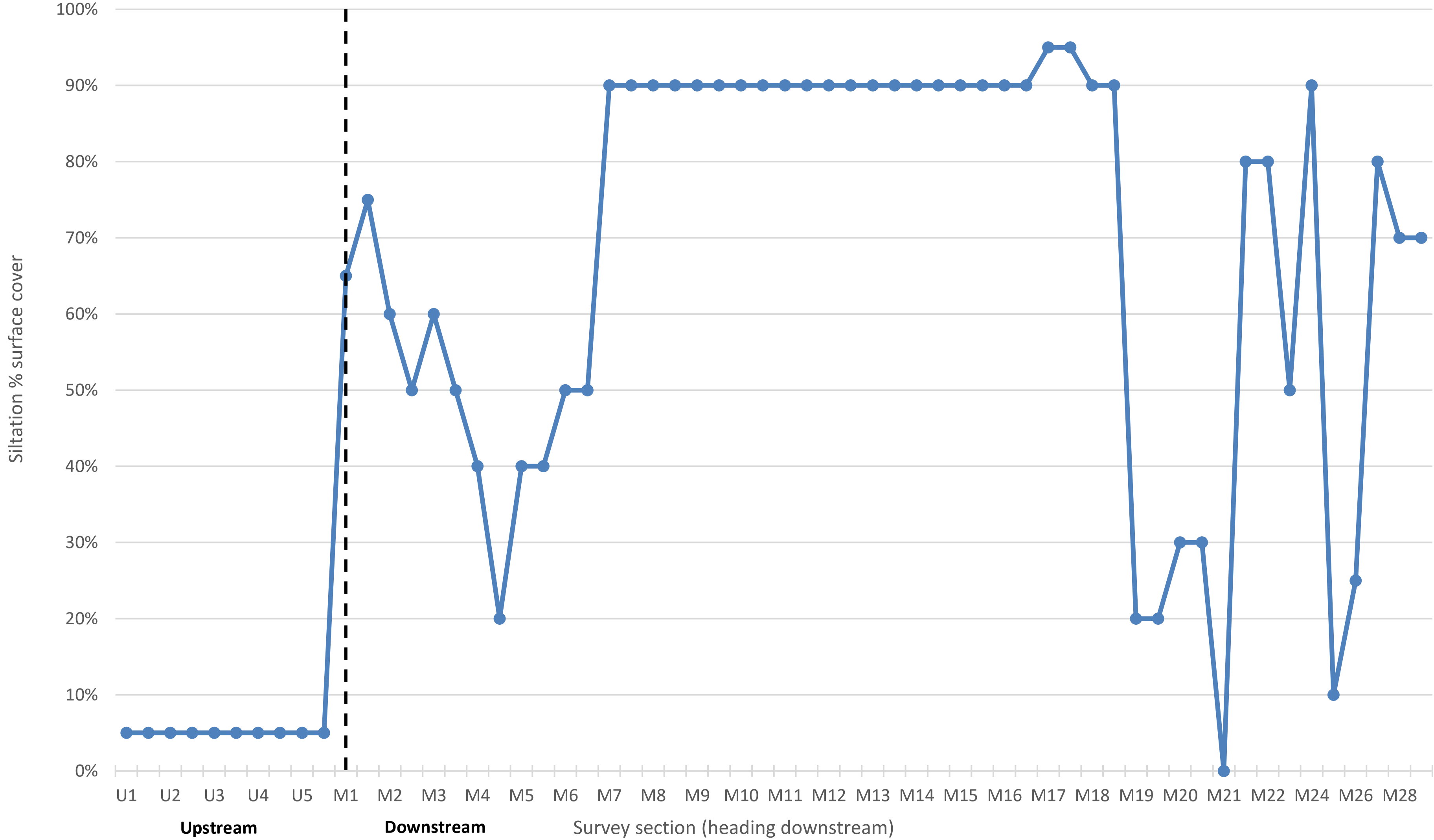

Figure 3.6 Percentage cover of siltation on the riverbed along the Mourne Beg River, July 2021 (dashed line indicates peat slide event). 0% = none, <5% = slight, <25% = moderate, >25% = severe siltation

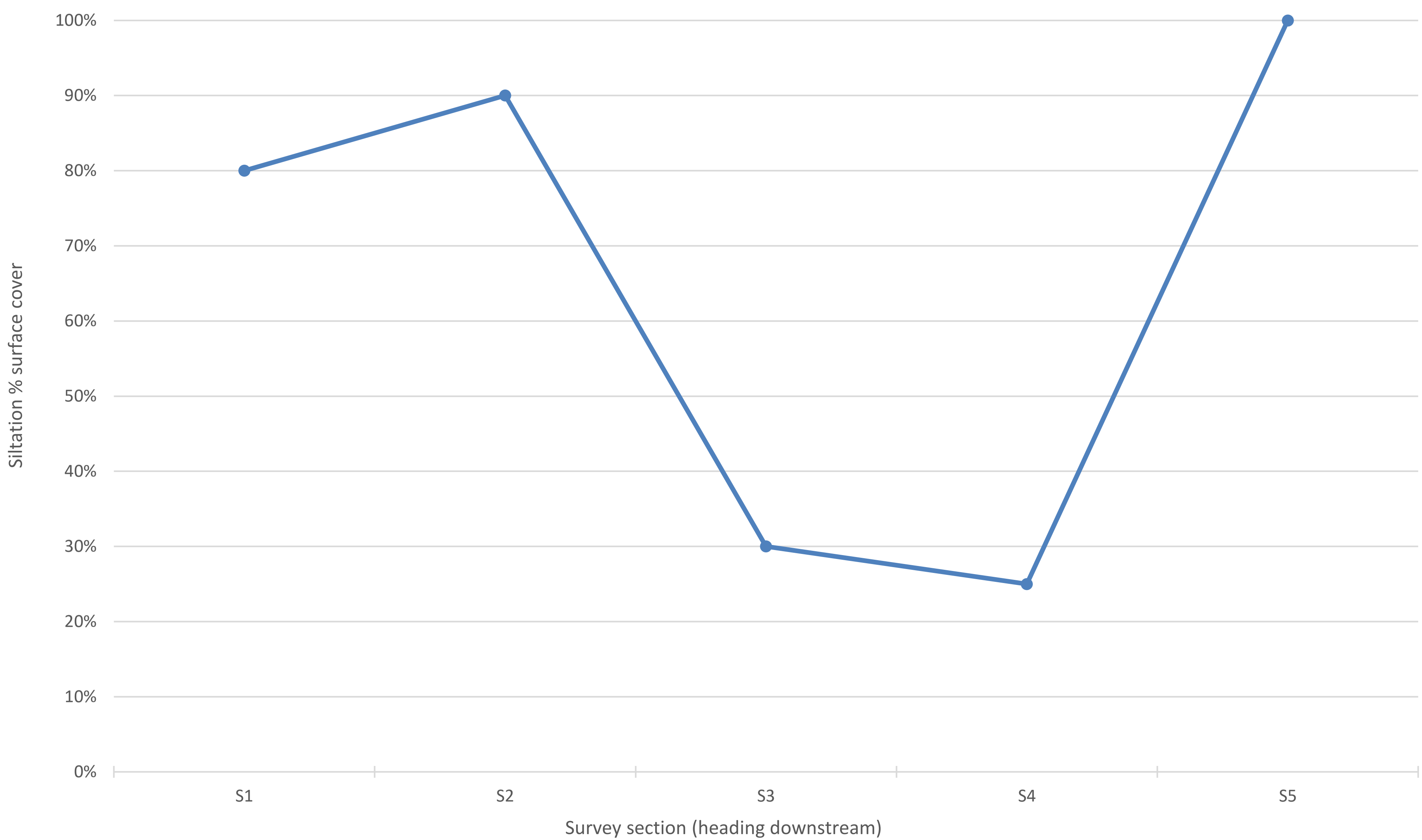

Figure 3.7 Percentage cover of siltation on riverbed along the Sruhangarve, July 2021. 0% = none, <5% = slight, <25% = moderate, >25% = severe siltation

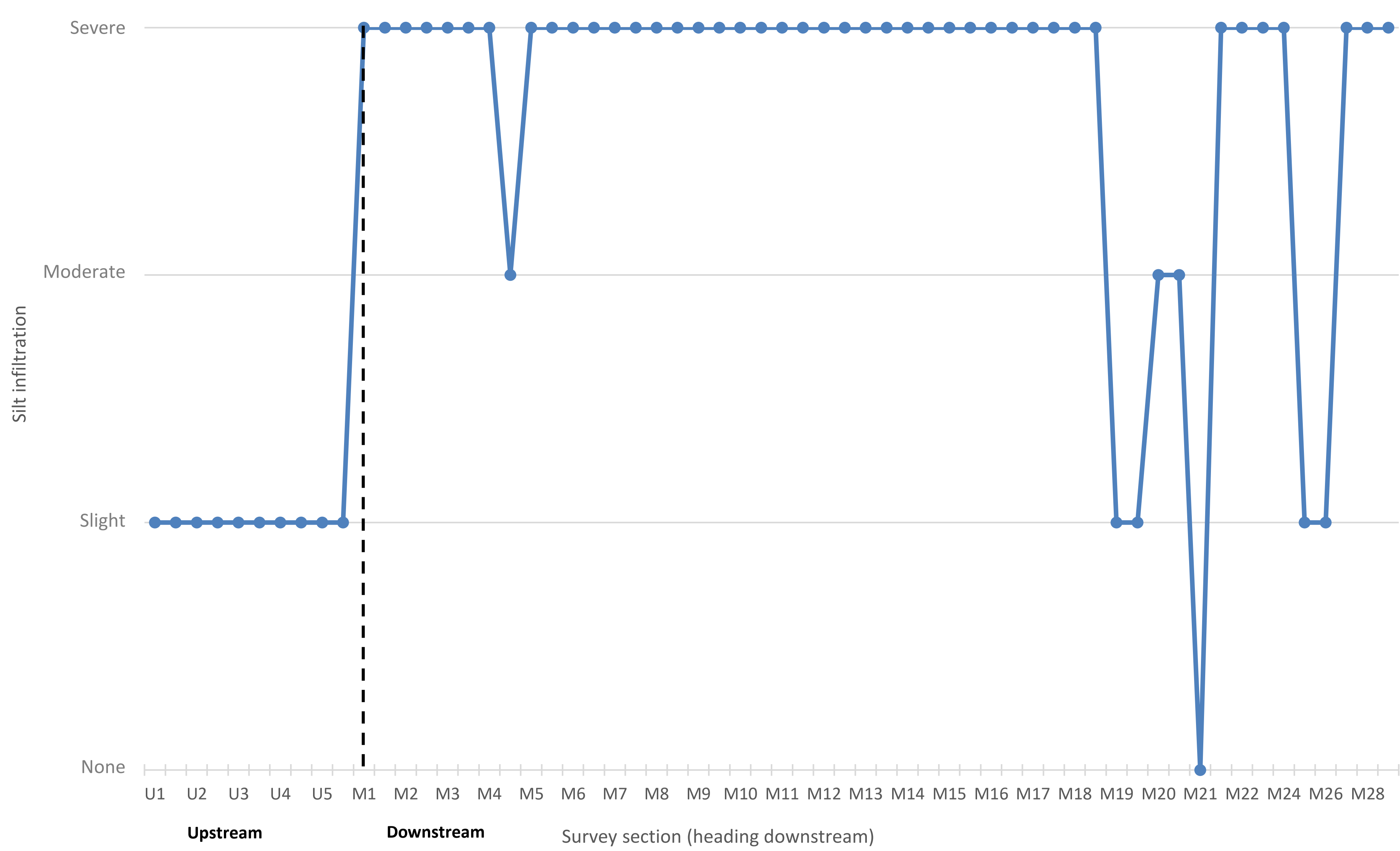

Figure 3.8 Level of silt infiltration of riverine substrata along the Mourne Beg River, July 2021 (dashed line indicates peat slide event)

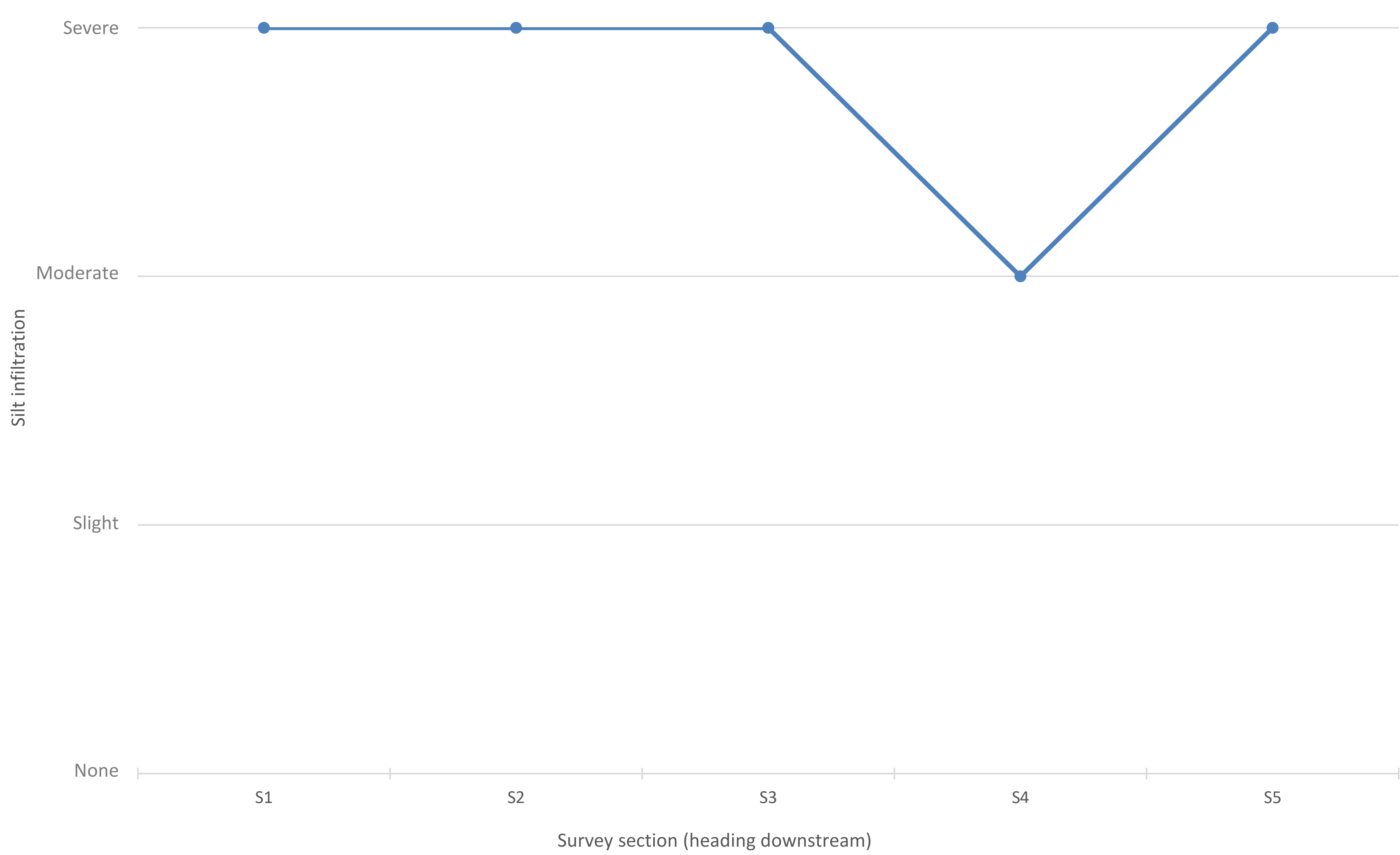

Figure 3.9 Level of silt infiltration of riverine substrata along the Sruhangarve, July 2021

3.3 Juvenile salmonid population trends (electro-fishing data)

Utilising the Lough's Agency electro-fishing data from the same 7 no. survey sites pooled, there were evident temporal changes in salmonid fry abundance between September 2020 (pre-impact) and June 2021 (post-impact) (**Figures 3.10-3.13; Tables 3.1 & 3.2**). The two survey sites located upstream of the Sruhangarve confluence (650m d/s Lough Mourne & 250m upstream Bunadowen-Mourne Beg confluence) supported very low numbers of 0+ Atlantic salmon fry (**Table 3.1**) and 0+ brown trout fry (**Table 3.2**) in both years, respectively. The abundance of Atlantic salmon fry showed a general positive trend (increase) moving downstream along the Mourne Beg River in both years with a considerable decline observed only at Meenreagh Bridge (station 05_022) **(Table 3.1)**.

For Atlantic salmon, there was either no change or an increase in juvenile (0+ and 1+) fish abundance in 5 of these 7 survey sites in June 2021 compared with September 2020 (**Figures 3.10 & 3.11**). The number of 0+ Atlantic salmon remained the same or increased at 6 of the 7 survey sites. There was a **62% increase** in the total number of juvenile Atlantic salmon recorded in June 2021 (*n*=89) compared with September 2020 (*n*=55).

However, in terms of brown trout abundance, there was a clear reduction in overall numbers of 0+ and 1+ fish in June 2021 compared with September 2020 (**Figures 3.12 & 3.13**). There were less 0+ trout recorded at all 7 no. comparable survey sites in June 2021, with trout absent from two survey sites (i.e. 250m upstream Bunadowen-Mourne Beg confluence and Mournebeg Bridge). There was an **81% decrease** in the total number of 0+ brown trout fry recorded in June 2021 (*n*=7) compared with September 2020 (*n*=37), with lower numbers recorded at all 7 no. survey sites (**Table 3.2; Figures 3.12 & 3.13**). The numbers of 1+ brown trout were slightly higher at the three survey sites upstream of the Sruhangarve in 2021 compared with 2020, but lower at all sites downstream (Loughs Agency data not shown). Similarly, the total numbers of numbers of brown trout (0+ and 1+ combined) increased or remained the same at the three survey sites upstream of the Sruhangarve confluence but decreased at all sites downstream (**Figure 3.15**).

For context, the total number of juvenile Atlantic salmon and brown trout recorded in the 2015-2021 period (excluding 2017, no data) are provided in **Figures 3.14** and **Figure 3.15**, respectively.

Table 3.1 Semi-quantitative abundance categories (Crozier & Kennedy, 1994) for **0+ Atlantic salmon fry** in September 2020 (pre-impact) and June 2021 (post-impact). Abundance categories shown as 5-minute CPUE equivalents

Site ID	Site	2020		2021	
		No. fry (10-min CPUE)	Abundance category (5-min CPUE)	No. fry (10-min CPUE)	Abundance category (5-min CPUE)
05_033	650m d/s Lough Mourne	1	Poor	0	Absent
05_032	250m upstream Bunadowen-Mourne Beg confluence[1]	2	Poor	2	Poor
05_031	Meenglass Bridge	4	Poor	13	Fair
05_023	Croagh Bridge	6	Poor	**11**	**Fair**
05_022	Meenreagh Bridge	18	Fair	**3**	**Poor**
05_019	Mourne Bridge	7	Poor	21	Fair
05_018	Mournebeg Bridge	18	Fair	39	Good
	Total	**55**		**89**	

Table 3.2 Semi-quantitative abundance categories (Kennedy, unpublished) for **0+ brown trout fry** in September 2020 (pre-impact) and June 2021 (post-impact). Abundance categories shown as 5-minute CPUE equivalents

Site ID	Site	2020		2021	
		No. fry (10-min CPUE)	Abundance category (5-min CPUE)	No. fry (10-min CPUE)	Abundance category (5-min CPUE)
05_033	650m d/s Lough Mourne	4	Poor	3	Poor
05_032	250m upstream Bunadowen-Mourne Beg confluence[1]	3	Poor	0	Absent
05_031	Meenglass Bridge	2	Poor	1	Poor
05_023	Croagh Bridge	3	Poor	2	Poor
05_022	Meenreagh Bridge	11	Fair	1	Poor
05_019	Mourne Bridge	6	Poor	2	Poor
05_018	Mournebeg Bridge	8	Poor	0	Absent
	Total	**37**		**7**	

[1] In 2020 this site was located at the Bunadowen River-Mourne Beg River confluence rather than on the Mourne Beg 250m upstream of this point

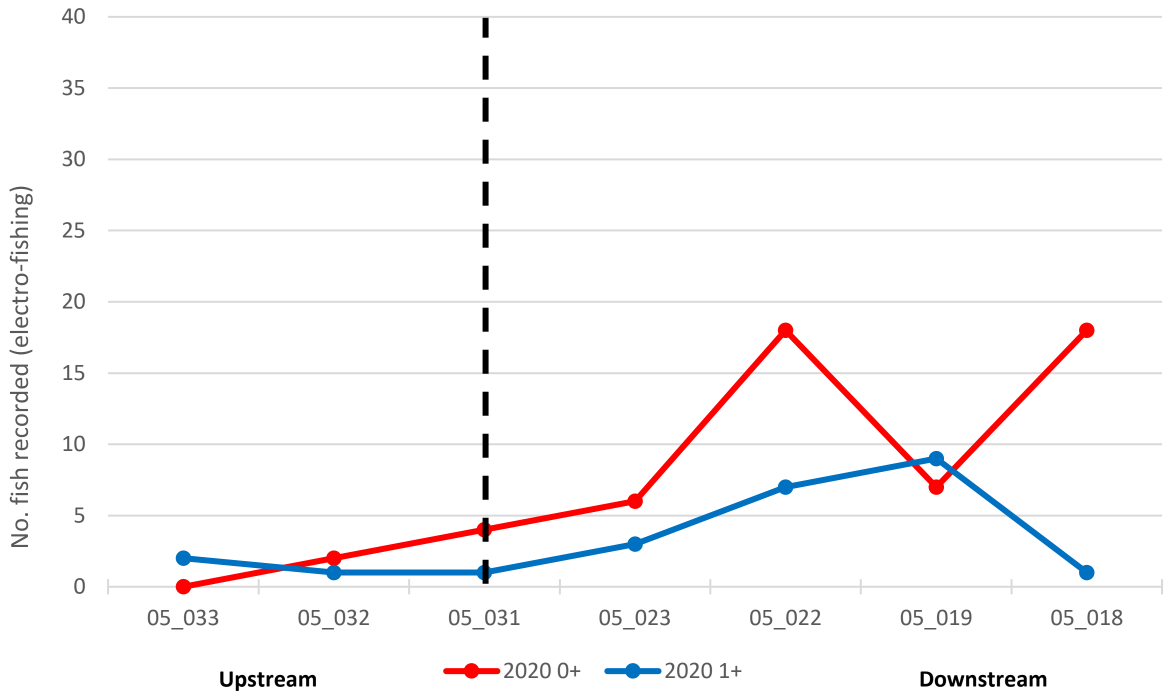

Figure 3.10 Numbers of 0+ & 1+ Atlantic salmon recorded via electro-fishing from the same 7 no. sites on the Mourne Beg River in **2020** (upstream to downstream). Dashed line indicates peat slide event location

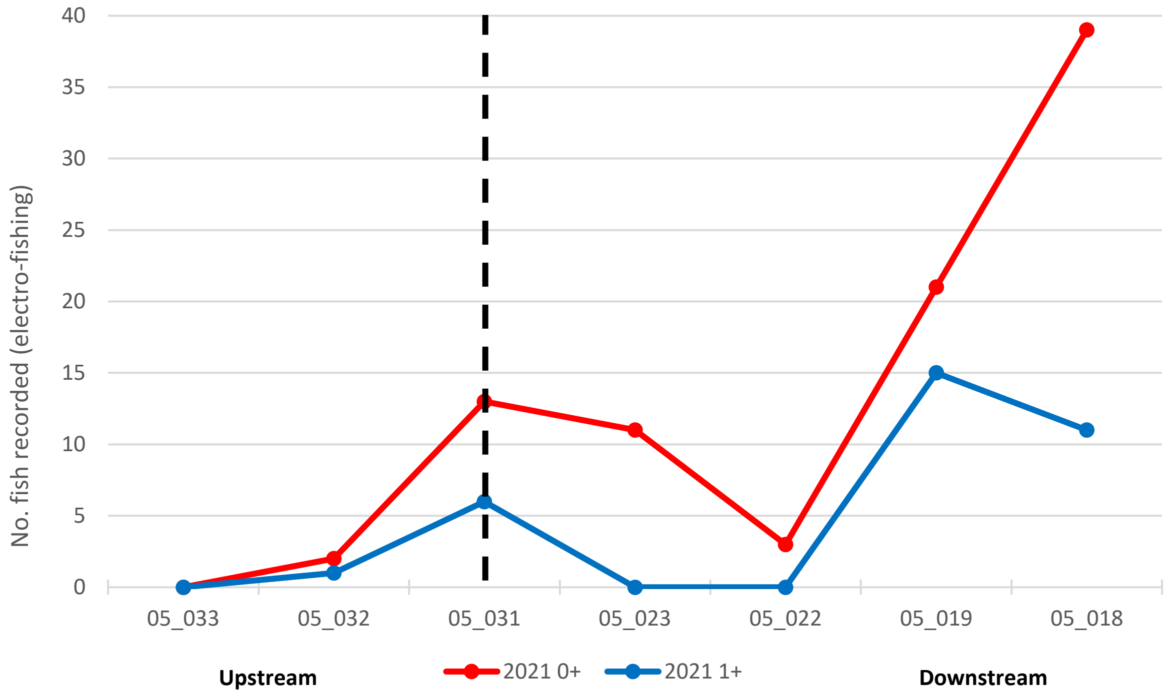

Figure 3.11 Numbers of 0+ & 1+ Atlantic salmon recorded via electro-fishing from the same 7 no. sites on the Mourne Beg River in **2021** (upstream to downstream). Dashed line indicates peat slide event location

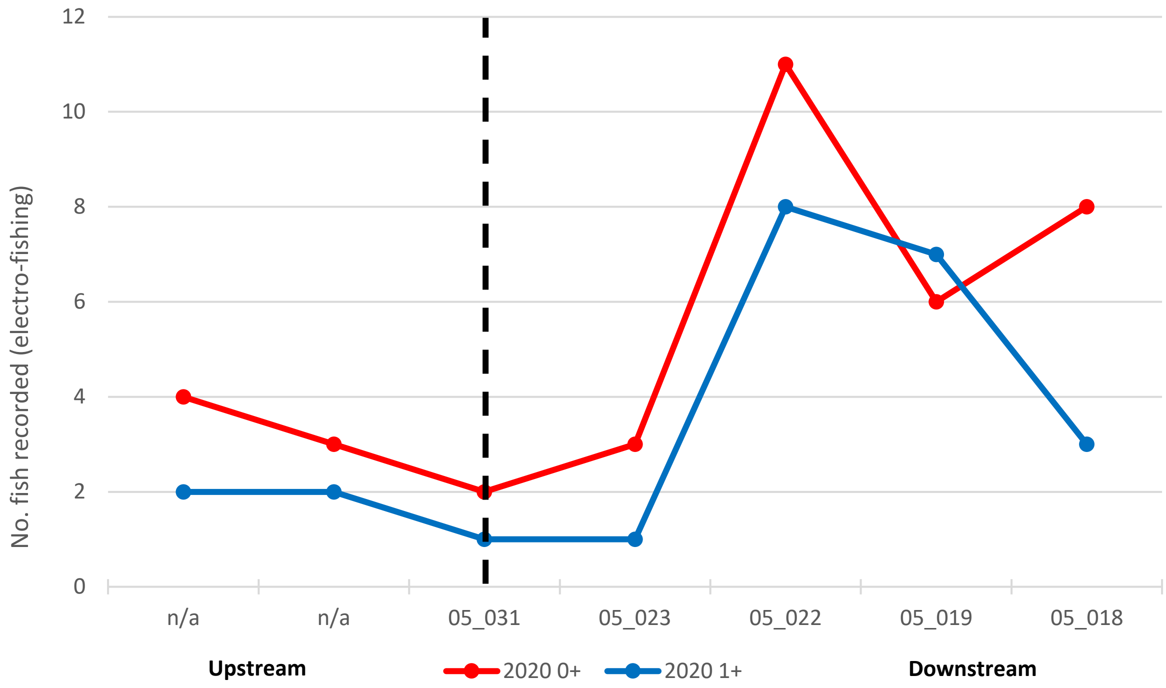

Figure 3.12 Numbers of 0+ & 1+ brown trout recorded via electro-fishing from the same 7 no. sites on the Mourne Beg River in **2020** (upstream to downstream). Dashed line indicates peat slide event location

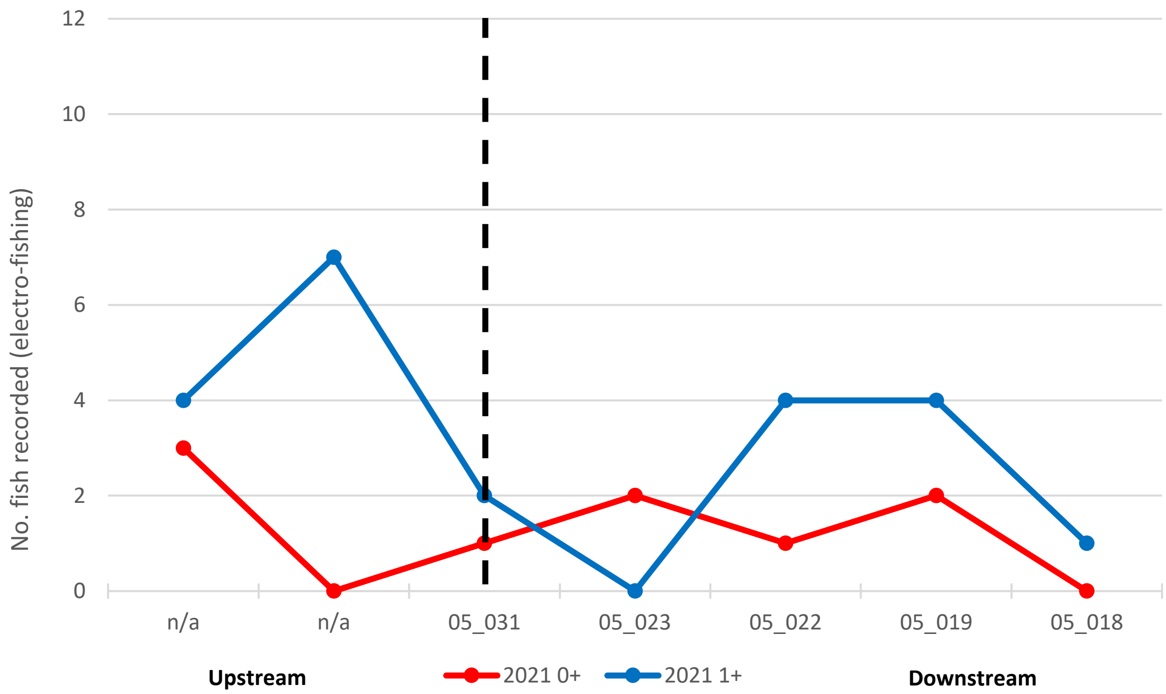

Figure 3.13 Numbers of 0+ & 1+ brown trout recorded via electro-fishing from the same 7 no. sites on the Mourne Beg River in **2021** (upstream to downstream). Dashed line indicates peat slide event location

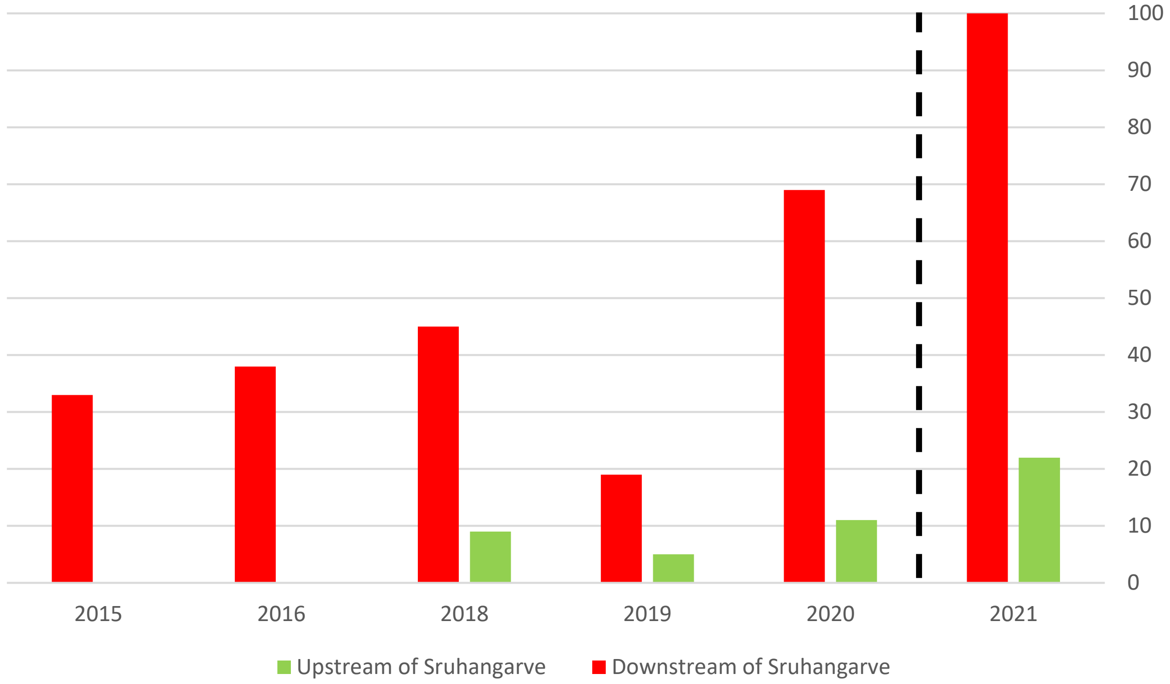

Figure 3.14 Total number of **Atlantic salmon juveniles (0+ & 1+)** recorded via electro-fishing from the same 7 no. sites on the Mourne Beg River in 2015-2021 (upstream to downstream). Dashed line indicates timing peat slide event

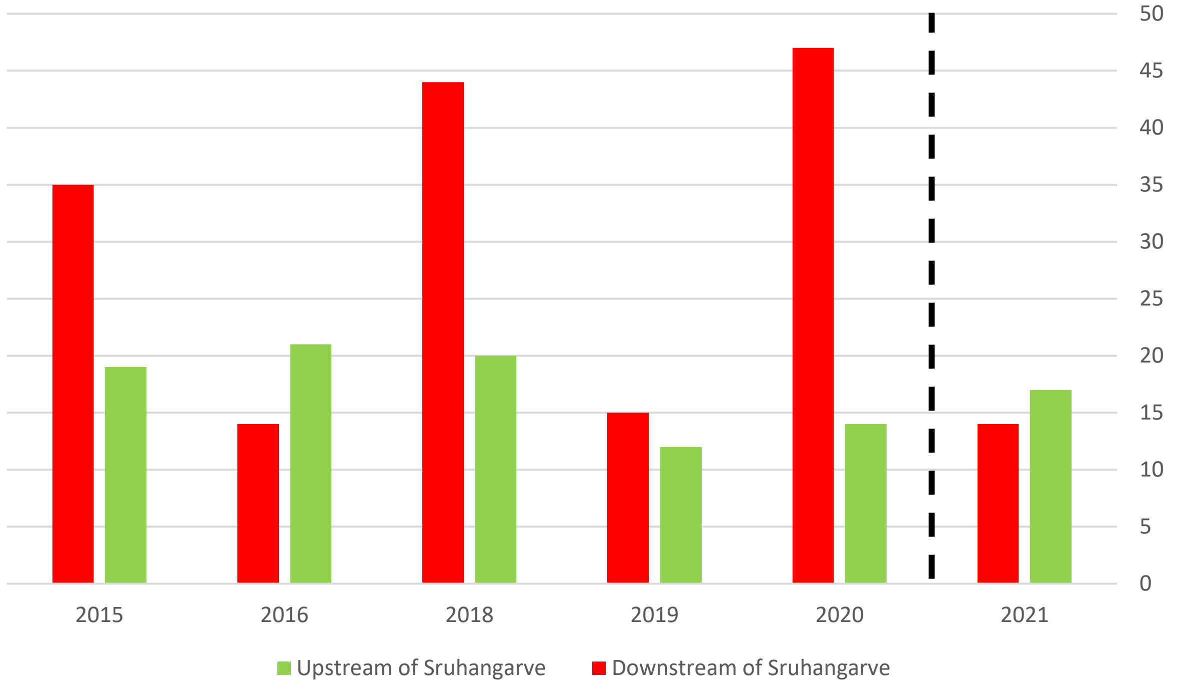

Figure 3.15 Total number of **brown trout (0+ & 1+)** recorded via electro-fishing from the same 7 no. sites on the Mourne Beg River in 2015-2021 (upstream to downstream). Dashed line indicates timing of peat slide event

3.4 Salmonid redd counts

Salmonid redd count data before (winter of 2019-20) and after the peat slide event (winter of 2020-21) is summarised in **Table 3.3** and shown in **Figures 3.5** to **3.7** below. Annual redd count data is presented in **Appendix B**.

There was a clear difference in the number and distribution of salmonid redds on the Mourne Beg River in the first spawning season after the peat slide event (i.e. winter of 2020-21). There was a marked reduction in both the total number and distribution of redds identified downstream of the Sruhangarve confluence compared with previous years (a total of just *n*=4 redds; **Table 3.3**).

In contrast, there was a noticeable increase in the number of redds upstream of the Sruhangarve confluence (*n*=37) compared with the previous year (*n*=2; 2019-20) (**Table 3.3**). Please note that redd count data for the 2011-12 to 2018-2019 periods on the Mourne Beg River upstream of the Sruhangarve confluence was not available.

Table 3.3 Salmonid redd count data per year (winter spawning season) for the Mourne Beg River (source: Loughs Agency)

Year	Upstream of Sruhangarve	Downstream of Sruhangarve	Total count
2020-21	37	4	41
2019-20	2	67	69
2018-19	0	32	32
2017-18	0	13	13
2016-17	0	44	44
2015-16	0	4	4
2014-15	0	32	32
2012-13	0	12	12
2011-12	0	7	7
Total	**39**	**215**	**254**

*no data available for the Mourne Beg River in the 2013-2014 period

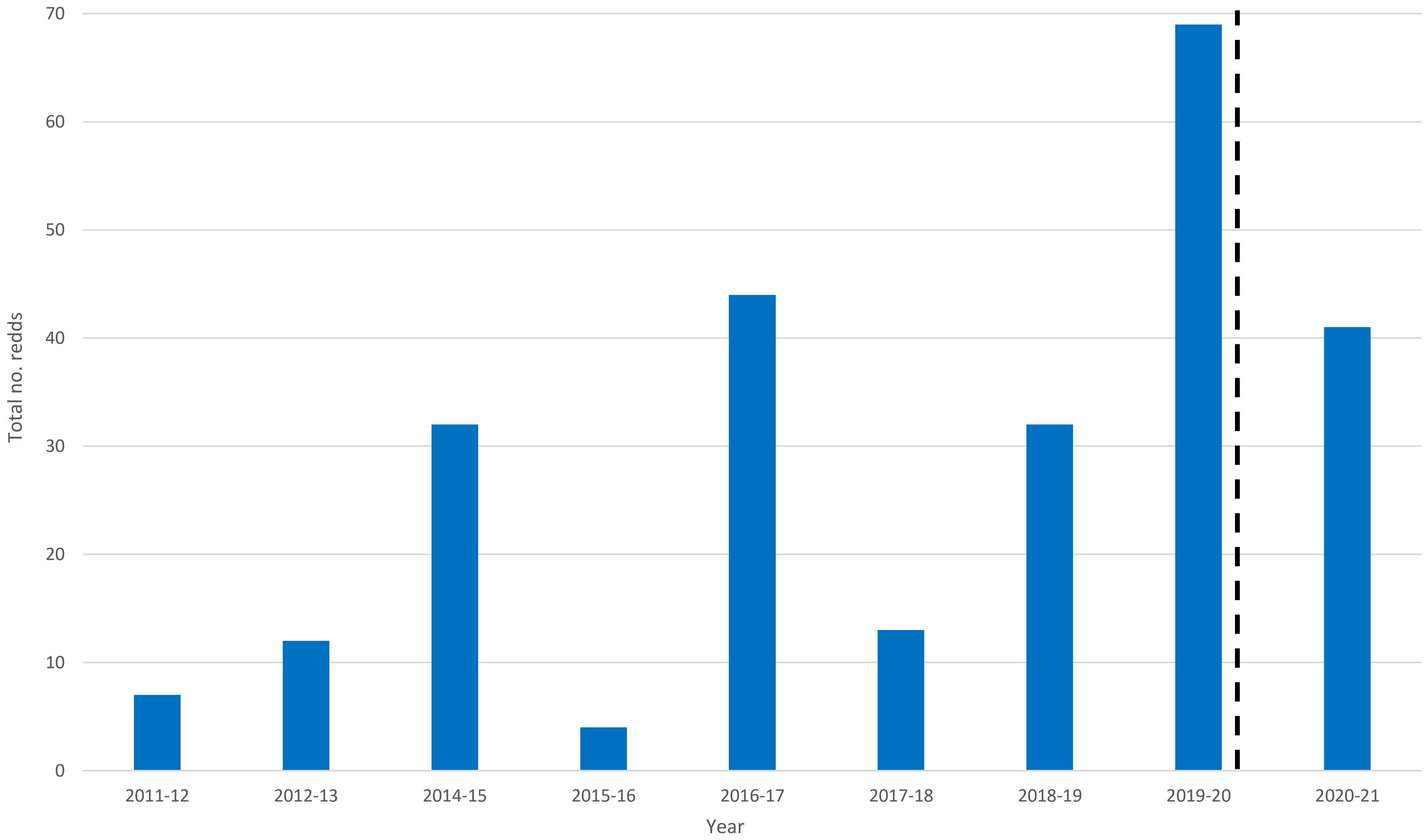

Figure 3.16 Total salmonid spawning redd counts for the Mourne Beg River (entire river) in the 2011-12 to 2021-2021 period (source: Loughs Agency) (no data available for the 2013-14 period). Dashed line indicates timing of peat slide event

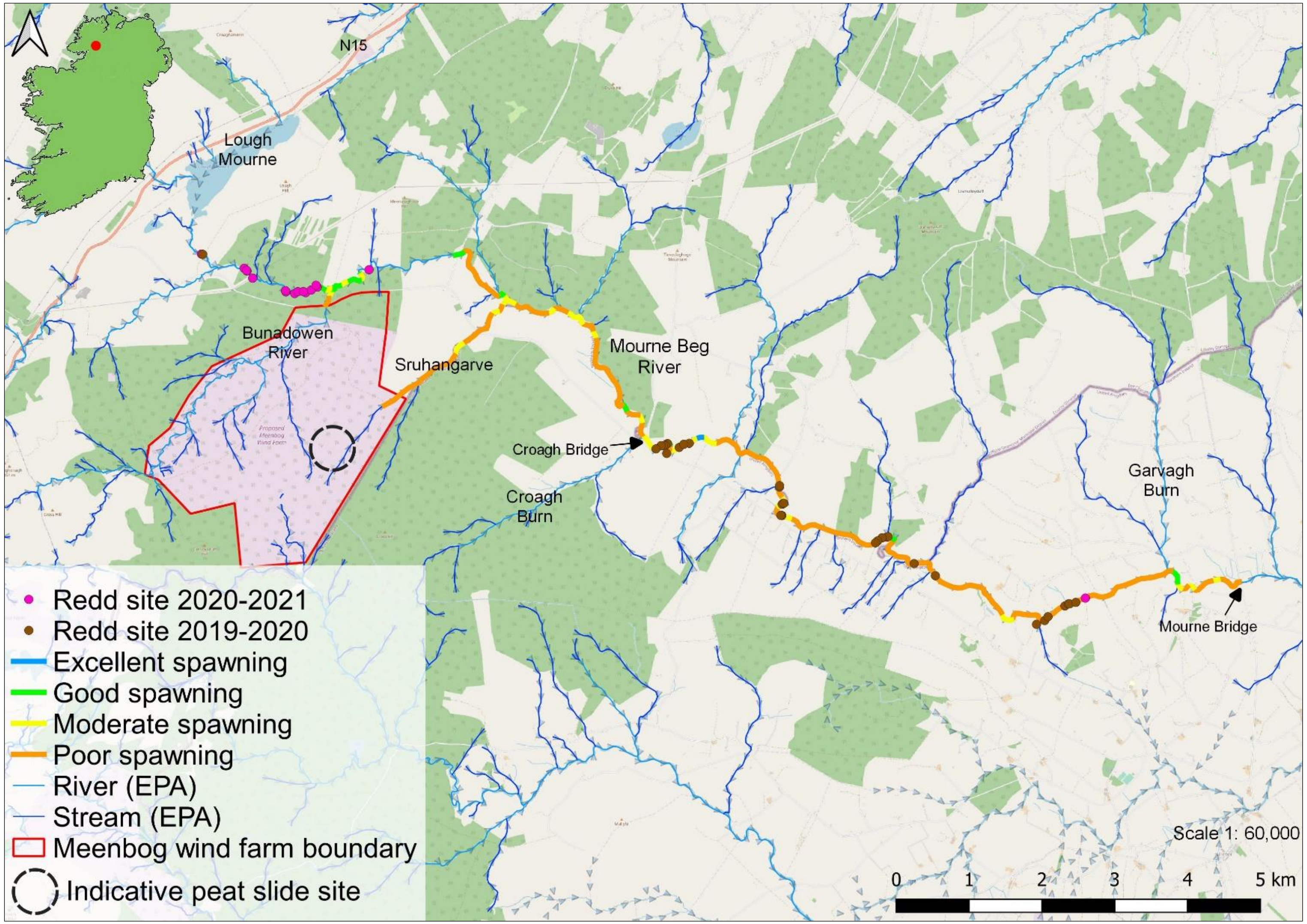

Figure 3.17 Distribution of salmonid spawning redds on the Mourne Beg River before (2019-20) and after the peat slide event (2020-21), with spawning habitat quality (Life Cycle Unit score) per 100m section

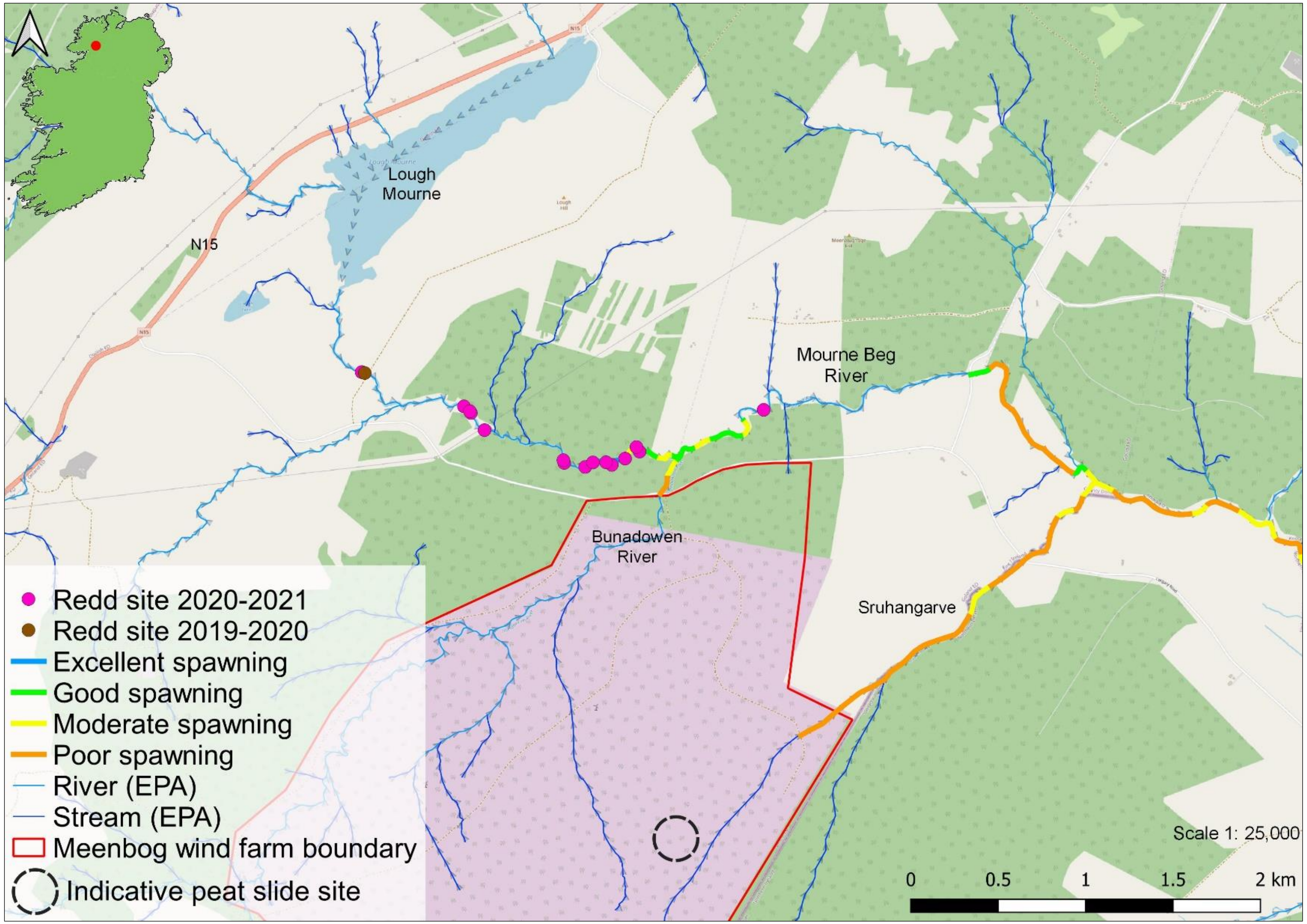

Figure 3.18 Distribution of salmonid spawning redds on the Mourne Beg River **upstream of the Sruhangarve** confluence before (2019-20) and after the peat slide event (2020-21), with spawning habitat quality (Life Cycle Unit score) per 100m section

3.5 River Hydromorphological Assessment Technique (RHAT) scores

Of the *n*=40 survey sections assessed for RHAT within the survey area, only section M4 achieved a RHAT score equivalent to **high WFD status** (i.e. hydromorph score ≥26) (**Appendix E; Figure 3.19**). This higher gradient, boulder-cascade section was located 1.5km downstream of the Sruhangarve confluence.

The majority of the survey sections (*n*=29) were equivalent to **good WFD status** (hydromorph score ≥19.5) (**Figure 3.19**). All 5 no. upstream control sections on the Mourne Beg River (U1-U5), in addition to the Bunadowen survey section (B1), were also equivalent to good WFD status (**Figure 3.19**).

Survey sections M20, M21 and M24 on the Mourne Beg River achieved **moderate WFD status** given significant water abstraction pressures and channel modifications (e.g. artificial weir in section M20). Sections M17 and M18 achieved **poor WFD status** given significant historical modifications (straightening and deepening) and resulting poor hydromorphology.

The upper survey sections on the Sruhangarve achieved RHAT scores equivalent to **poor WFD status** (S1) and **moderate WFD status** (S2 & S3). However, the lower 1km of the Sruhangarve channel (Sections S4 & S5) were considered of good WFD status (**Appendix E; Figure 3.19**).

3.6 Biological water quality (macro-invertebrates)

No rare or protected macro-invertebrate species (according to national red lists) were recorded in the biological water quality samples taken from *n*=9 riverine sites in October 2021 (**Figure 3.20, Appendix F**).

Sites M4 and M5 on the Mourne Beg River achieved **Q4-5 (high status)** water quality, based on Q-sampling, and thus met the good status (≥Q4) requirements of the European Union Environmental Objectives (Surface Waters) (Amendment) Regulations 2019 and the Water Framework Directive (2000/60/EC). Additionally, 6 no. sites, namely site B1 on the Bunadowen River and sites M2, M3, M6, M7 and M8 on the Mourne Beg River obtained **Q4 (good status)** and thus also met the requirements of the of the European Union Environmental Objectives (Surface Waters) (Amendment) Regulations 2019 and the Water Framework Directive (2000/60/EC). Only two sites, M1 on the Mourne Beg River and site S1 on the Sruhangarve, obtained **Q3-4 (moderate status)** and thus failed to meet the good status (≥Q4) requirements of the European Union Environmental Objectives (Surface Waters) (Amendment) Regulations 2019 and the Water Framework Directive (2000/60/EC) (**Figure 3.20**).

It is clear that when comparing the biological water quality data between October 2021 and December 2020 that there is a significant improvement between the two periods (**Table 3.4, Figures 3.20 & 3.21**). The biological water quality improved across each of the five comparative sampling stations both upstream and downstream of the peat slide impact contribution area (i.e. Sruhangarve confluence). All of the sampling sites achieved the good status (≥Q4) requirements of the European Union Environmental Objectives (Surface Waters) (Amendment) Regulations 2019 and the Water Framework Directive (2000/60/EC).

Table 3.4 Comparative Q-sample results between biological sampling stations in December 2020 and October 2021 (both after the peat slide event)

Survey station	Area	Q-rating Dec 2020	Q -rating Oct 2021
M2 (Bunadowen confluence)	u/s Sruhangarve confluence	Q4 (good status)	Q4-5 (high status)
M4 (Sruhangarve confluence)	u/s Sruhangarve confluence	Q4 (good status)	Q4-5 (high status)
M5 (Croagh Bridge)	d/s Sruhangarve confluence	Q4 (good status)	Q4-5 (high status)
M6 (Meenreagh Bridge)	d/s Sruhangarve confluence	Q3-4 (moderate status)	Q4 (good status)
M8 (Mourne Bridge)	d/s Sruhangarve confluence	Q3-4 (moderate status)	Q4 (good status)

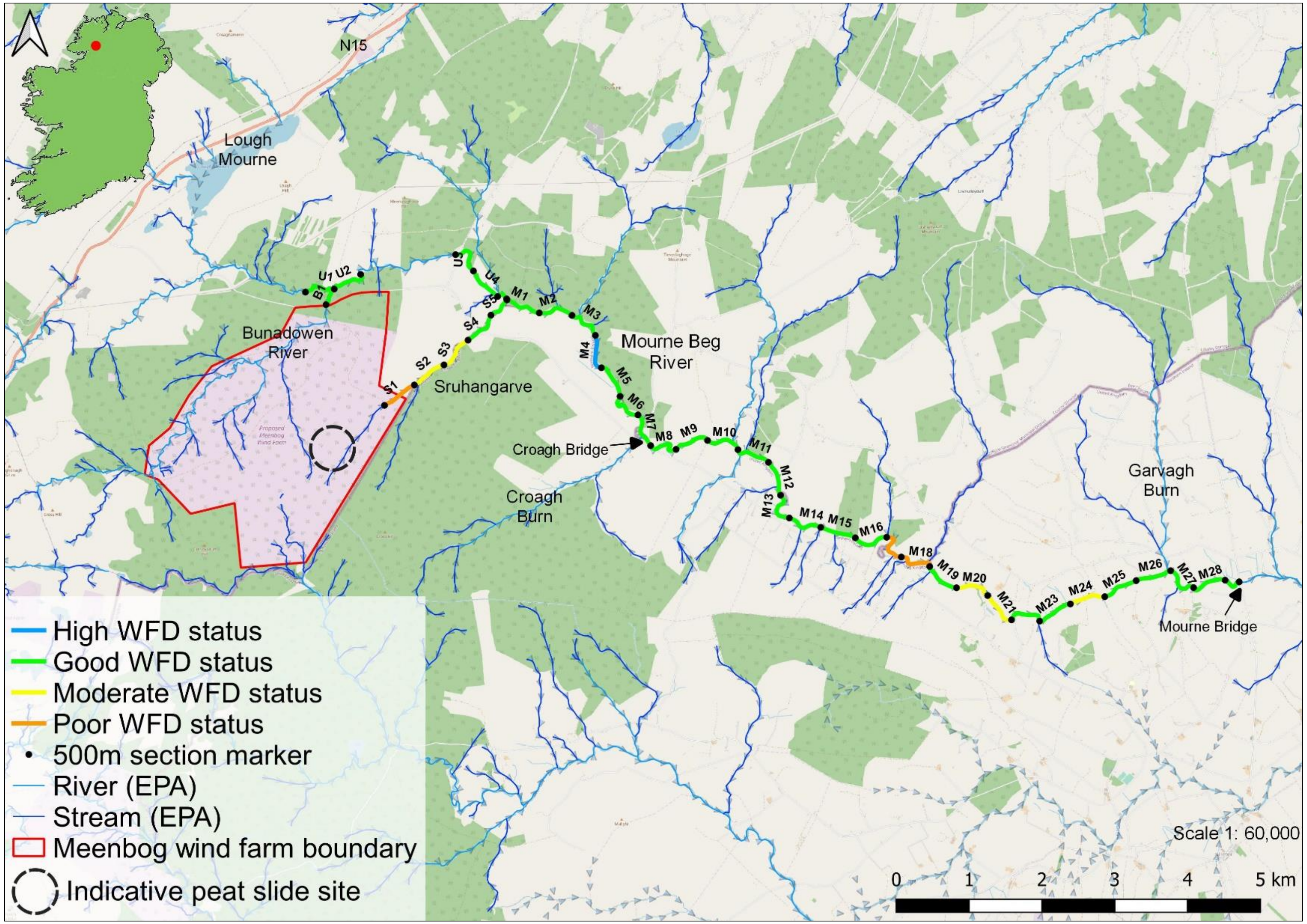

Figure 3.19 RHAT scores per survey section on the Mourne Beg River, Bunadowen River and Sruhangarve, July 2021

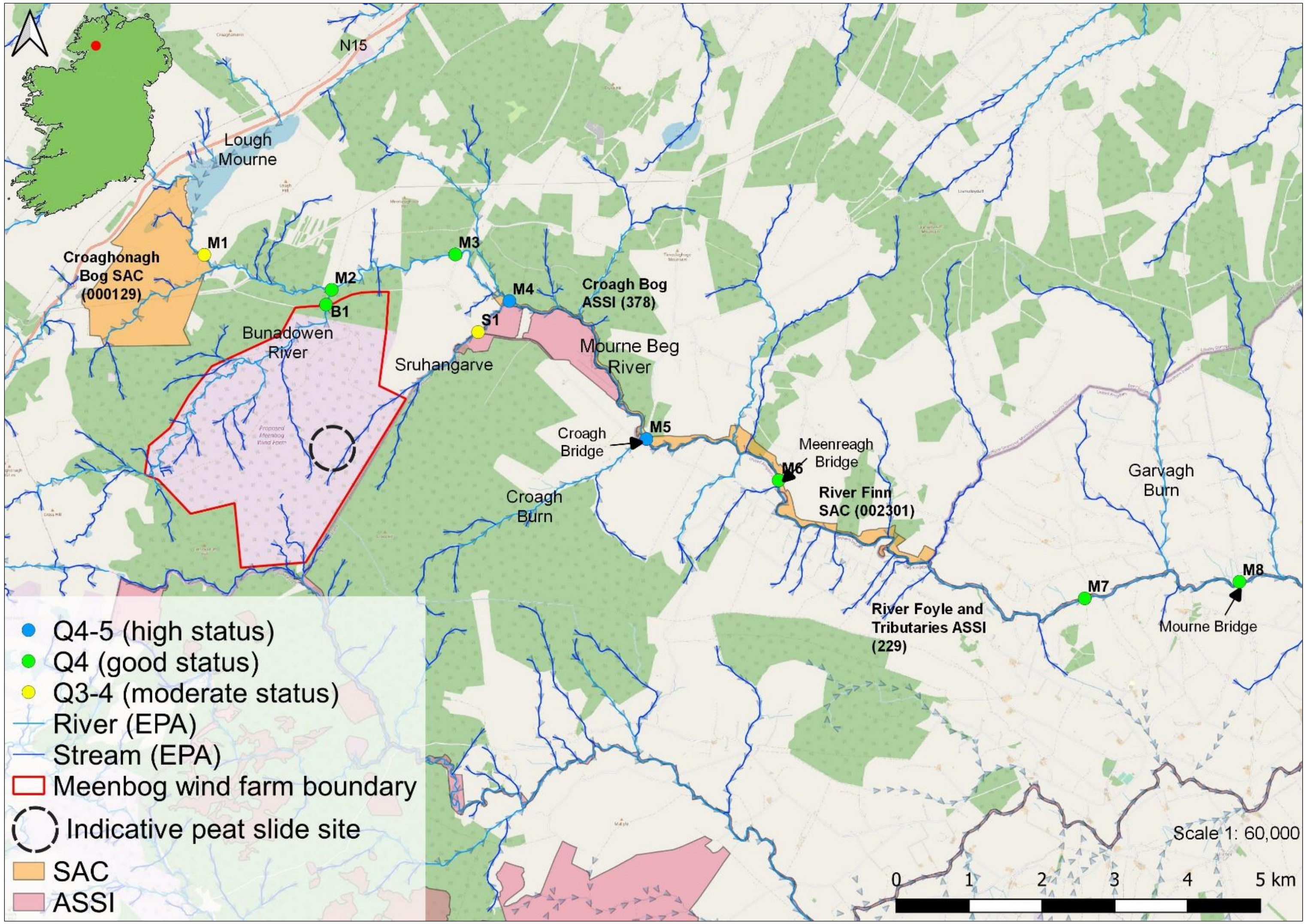

Figure 3.20 Biological water quality of the Mourne Beg River, Bunadowen River and Sruhangarve survey sites, **October 2021**

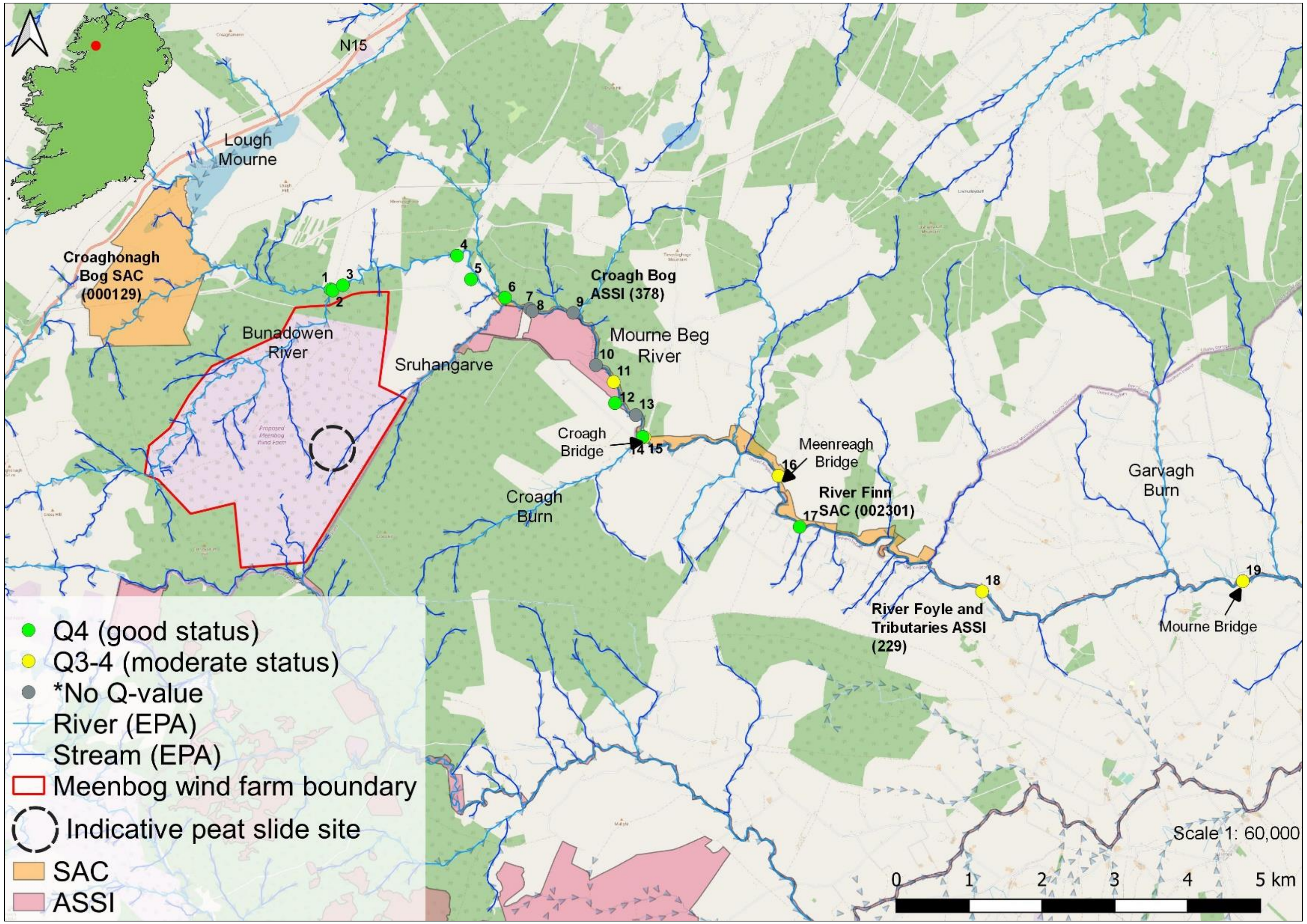

Figure 3.21 Biological water quality of the Mourne Beg River and Bunadowen River sampling stations (1-19), **December 2020** (MKO data) (*no Q-value calculation possible given absence or paucity of macro-invertebrates at time of sampling: MKO, 2020)

4. Discussion

The current study has examined and considered the implications of peat-related impacts for fish, macro-invertebrates including associated biological water quality, river hydromorphology and physical habitats within the Mourne Beg River and its tributary, the Sruhangarve. Whilst this study has identified clear deteriorations in the quality of aquatic habitat as a result of the November 2020 peat slide event, recovery of both fish and macro-invertebrate populations is evident from the results. Our results have also highlighted other pre-existing and ongoing synergistic pressures within the wider catchment, including afforestation and agricultural land use practices.

4.1 Influence of peat slide on salmonids

4.1.1 Salmonid populations

The negative impacts of sediment loading on salmonid populations are well documented and vary widely, from effects on fish physiology, reproductive success and migratory behaviour to epigenetics and habitat quality (see Kjelland et al., 2015; Chapman et al., 2014 for reviews). Sediment not only blocks interstitial spaces in substrata and limits oxygen supply to salmonid eggs (required for healthy embryonic development and successful hatching) but can also smother substrata, thus reducing available spawning habitat and impact macro-invertebrate communities on which salmonids feed (Kelly-Quinn et al., 2020; Davis et al., 2018; Conroy et al., 2016; Cocchiglia et al., 2012; Louhi et al., 2008, 2011; Walling et al., 2003; Soulsby et al., 2001).

With the Lough's Agency electro-fishing data from the same 7 no. survey sites pooled, there were evident temporal changes in salmonid fry abundance between September 2020 (pre-impact) and June 2021 (post-impact) (**Figures 3.10-3.13; Tables 3.1 & 3.2**). For Atlantic salmon, there was either no change or an increase in juvenile (0+ and 1+) fish abundance in 5 of these 7 survey sites in June 2021 compared with September 2020, with a **62% increase** in the total number of juvenile 0+ Atlantic salmon recorded in June 2021 (*n*=89) compared with September 2020 (*n*=55) (**Table 3.1; Figure 3.14**). In contrast, there was a reduction in overall numbers of brown trout in June 2021 compared with September 2020 (**Figure 3.15**), with an **81% decrease** in the total number of juvenile (0+) brown trout recorded in June 2021 (*n*=7) compared with September 2020 (*n*=37) (**Table 3.2**). There were less trout (0+, 1+ and total combined numbers, respectively) recorded at all survey sites downstream of the Sruhangarve confluence in June 2021.

Salmonid populations are subject to natural fluctuations due to temporal and stochastic environmental factors (Milner et al., 2003) and thus annual abundance data should be reviewed and interpreted with caution. Nevertheless, there has been a general positive trend in Atlantic salmon numbers on the Mourne Beg River in the 2015-2021 period (**Figure 3.14**), with the highest abundances recorded in June 2021 (after the peat slide event). Whilst there was a noticeable shift and restriction in spawning habitat utilisation after the peat slide (see section 4.1.2 below), the abundance of Atlantic salmon showed a general positive trend (increase) moving downstream along the Mourne Beg River (**Figure 3.10**). Despite the increase in utilisation of spawning areas upstream of the Sruhangarve confluence after the peat slide (winter 2020-21; **Figure 3.17; Appendix B**), electro-fishing data suggests that, counter-intuitively, numbers of juvenile salmon remained low upstream of the impact zone. Upon emergence from redds, fry often disperse downstream in search of habitat optimal for their growth and development (Marsh et al., 2020). Furthermore, it is possible that Atlantic salmon dropped downstream due to density dependence (Armstrong, 2005) and occupied the niche space vacated by brown trout (see below), thus explaining the higher numbers recorded within the peat slide impact zone. Alternatively, given the suitable nursery conditions in these upstream areas (adjoining good to excellent-quality spawning habitat), it may be that other environmental stressors are influencing salmonid population dynamics in the upper catchment (see **section 4.5**).

In contrast to salmon, the brown trout population of the Mourne Beg River demonstrated a noticeable decline after the peat slide (comparing electro-fishing data between years) (**Figure 3.15**). Given the timing of the peat slide event (13th November 2020), it is possible that many of the Mourne Beg River adult brown trout population had already spawned and deposited eggs into redds (brown trout spawning can occur as early as October in Irish rivers; pers. obs.). Atlantic salmon typically spawn later than brown trout (November/December), including in the wider Foyle River system (Niven, 2008). Loughs Agency redd count data suggests that Atlantic salmon spawned after the peat slide event (December 2020 to January 2021). Therefore, salmon eggs laid in this period may have avoided the most severe after-effects of the peat slide (i.e. gross sedimentation and smothering of redds & eggs).

The early fry stage, when the fish change from endogenous to exogenous feeding, has a high mortality rate, typically due to limitations on food and available foraging habitat, and has been described as a "critical period" in survival of Atlantic salmon (Honkanen et al., 2019). The development of salmonid embryos in inter-gravel habitats of the hyporheic zone[2] depends strongly on the influences of temperature, flow velocity, permeability of the sediment (amount of fine sediment) and consumption by organic processes on oxygen concentrations (Smialek et al., 2021; Harrison et al., 2019; Greig et al., 2007, 2005; Malcolm et al., 2004; Crisp, 1990). The persistence of high concentrations of fine sediments in watercourse substrata lowers the oxygen concentration of water within interstitial spaces and decreases substratum permeability, leading to increased embryo mortality due to insufficient supply of water and oxygen (Sternecker et al., 2013a; Sear & DeVries, 2008; Chapman, 1988; Olsson & Persson, 1986). Deoxygenation is most problematic when a substantial proportion of the infiltrating sediments are organic, e.g. peat (Soulsby et al., 2001). Interstitial flows within the incubation zone may also be reduced due to excess sedimentation, impeding on the removal of metabolic waste products produced by developing embryos (Cardenas et al., 2016). High amounts of fine sediment also affect the macro-invertebrate community and can, therefore, reduce prey availability for juvenile salmonids (Suttle et al., 2004). It is considered likely that fry exposed to high sedimentation as developing embryos suffer a reduction in fitness (swimming performance), increasing their vulnerability at the transition stage from intra-gravel to open-water life and resulting in sub-lethal affects at subsequent life stages (Louhi et al., 2011). The conditions for egg and larval development can strongly influence subsequent growth, survival and reproductive fitness (Russell et al., 2012).

Thus, perhaps in contrast to Atlantic salmon, already-developing trout embryos may have been exposed to the full, immediate impact of the peat slide event (i.e. sedimentation) in the Mourne Beg

[2] the hyporheic zone is one of the key elements of river corridors, being the portion of sediments surrounding the stream that is permeated with stream water (Boano et al., 2014)

River, leading to a reduction in the numbers of 0+ juveniles observed during subsequent electro-fishing surveys (June 2021). Brown trout have a greater proclivity to deeper slower-flowing areas of habitat compared with Atlantic salmon parr (Armstrong et al., 2003). Thus, the reduction in numbers of ≥1+ trout captured in the Mourne Beg River after the peat slide event may be explained by higher mortality rates in those areas of channel supporting greater sediment loads (e.g. glide and pool).

With regards to the Sruhangarve, the large volume of peat evidently caused considerable negative impacts to instream habitats via gross siltation (colmation). An event of this magnitude would have also caused widespread fish mortality within the stream. Although fisheries data from before the peat slide is lacking, since the peat slide event (November 2020) the Sruhangarve is known to support European eel and a low density of ≥1+ brown trout (Loughs Agency data; Paul Johnston Associates, 2017). Atlantic salmon are not known to utilise the Sruhangarve. This fish community structure is typical of narrow, upland watercourses, with stream gradient known to be one of the principal determinants of juvenile salmonid production - medium gradient channels are most optimal in terms of successful recruitment and population persistence (Wood & Budy, 2009; O'Grady, 2006; Amiro, 1993). Despite its high gradient and flow velocities, siltation was moderate to severe in the Sruhangarve (especially in the lower reaches) and impacts to salmonid life stages are likely to continue for an indefinite period.

4.1.2 Salmonid spawning habitat (redd counts)

Whilst the field identification of salmonid redds is subjective, open to various error sources and influenced by environmental stochasticity (Gallagher et al., 2007; Roncoroni & Lane, 2019), it remains a useful technique in assessing adult salmonid populations and the distribution of spawning sites (Dauphin et al., 2010). The Loughs Agency redd data collated in this study indicates a considerable reduction in both the total number and distribution of salmonid redds on the Mourne Beg River in the first spawning season after the peat slide event (i.e. winter of 2020-21). Whilst salmonid redd formation and utilisation naturally fluctuates from year to year due to a multitude of factors, the observed marked restriction in spawning site distribution in the 2020-21 spawning period (**Table 3.3; Figure 3.16**) is clearly linked to sediment (peat) related impacts on the fish population.

The impacts on spawning salmon are supported in that the known spawning zone immediately downstream of the Sruhangarve confluence was not utilised by spawning salmonids in the 2020-21 period (no redds recorded), despite being used annually[3] before the peat slide (**Appendix B**). Similarly, no redds were identified in the known spawning areas downstream of Croagh Bridge and Meenreagh Bridge in the winter of 2020-21 (**Appendix B**). In contrast, there was a noticeable increase in the number of redds upstream of the Sruhangarve confluence (*n*=37) compared with the previous year (*n*=2; 2019-20) (**Table 3.3**). Whilst siltation was still evident upstream of the Sruhangarve (due to non-peat slide sources, see section 4.5), the percentage surface cover by siltation of riverine substrata and infiltration into same was considerably lower than downstream areas impacted by the peat slide (see section 4.2 below & **Appendix D**). It appears likely that Atlantic salmon (and to a lesser degree brown trout) selected habitat further up the Mourne Beg River than normal during the first spawning season after the peat slide in response to changing environmental conditions (i.e. severe siltation of annually

[3] Atlantic salmon are philopatric and tend to spawn in the same locations annually (Hendry et al., 2004)

utilised spawning areas). There is also the possibility that severe siltation on the Mourne Beg River downstream of the Sruhangarve confluence covered recently constructed redds and made them less visible to observers during this period. Continued annual monitoring of salmonid redds on the system will clarify any changes in spawning site selection building upon the work of Loughs Agency.

Episodic inputs of large volumes of sediment, such as that originating from the Meenbog peat slide, can reduce the quality and or extent of available spawning habitat (through colmation) and lead to the superimposition[4] of redds, which can damage or dislodge eggs, causing mortality, and have genetic implications for the wider population (Dudley, 2019). This could result in changes to salmonid population dynamics. The deposition of fine sediments may also form a physical barrier within redds to emerging fry with carry-over effects on timing of emergence, survival rate, and post-hatch growth of juvenile salmonids (Sternecker & Geist, 2010). During redd formation, adult salmonids physically remove significant amounts of fine sediment from the site of egg deposition (Cardenas et al., 2016) but the success of this behaviour on embryonic development and hatching will depend on numerous factors, including sediment resuspension which would be continually high during an extreme peat slippage event.

4.2 Influence of peat slide on riverbed condition (redox potential & siltation)

With only a few exceptions (e.g. section M5), there was a higher percentage loss in redox potential moving downstream along the Mourne Beg River (**Figure 3.4; Appendix C**). This clearly indicates long-distance sediment mobilisation and impacts, i.e. not only confined to near the Sruhangarve confluence. Indeed, examinations of rates of substrata compaction, siltation (% surface cover) and silt infiltration (substrate depth of 5cm) (see **section 3.2.2**) confirmed that severe siltation and embeddedness[5] was an issue throughout the Mourne Beg River survey area, extending to >14km downstream of the Sruhangarve confluence.

The observed pattern of gross siltation is likely reflective of the volume of material from the peat slide, in addition to the ongoing resuspension of fines from gravel bed "sinks" (Wharton et al., 2017). On a spate system such as the Mourne Beg, this process (also known as de-colmation) is exacerbated by freshets (heavy rainfall leading to floods) which cause the remobilisation of sediment downstream (Zimmermann & Laporte, 2005). Detailed observations made in June 2021 suggest that whilst shallower, faster-flowing areas of river may recover over time, the deep glide and depositional pool areas (salmonid holding habitat) supported significant sediment loads. Given the high volumes of sediment (peat) within the system, the longitudinal resuspension of fines downs the Sruhangarve and Mourne Beg River is anticipated to last, and cause impacts, in the medium term, e.g. covering/smothering of dug redds. However, peat stabilisation efforts including in channel and riparian remediation will help reduce the impacts of peat escapement from the source area in the Sruhangarve over time.

[4] defined as the creation of a redd on top of a previously established redd (Dudley, 2019)

[5] in stream habitat assessment, the extent of fine sediment accumulation around coarse-bed grains is described as embeddedness (Sennatt et al., 2006)

Over 80% of redox replicates on the Mourne Beg River downstream of the Sruhangarve demonstrated a substrata redox potential below 300mV, with a mean redox loss typically greater than 10% (up to 31% loss). This was in contrast to the upstream control area on the river, where approximately half of the replicates demonstrated a substrata redox potential below 300mV (**Appendix C**). Redox values below 300mV are indicative of anoxic conditions (Geist & Auerswald, 2007). A loss of redox potential between the water column and the sediment greater than 25% indicates oxygen depletion in the substrate (Gosselin et al., 2015), with losses in redox of over 30% generally indicative of a highly silted environment, severely depleted in interstitial oxygen to the point of anoxia (Moorkens & Killeen, 2020). Riverbed redox state is co-dependent with other factors such as deposition rate, organic matter flux, benthic faunal activities, and bottom water oxygen concentration (Sear et al., 2016). The presence of biological activity driven by organic matter (e.g. peat) can generate the formation of biofilms, that block the interstitial pores of gravels and decomposition of the organic matter restricts oxygen to incubating salmonid embryos (Smialek et al., 2021; Greig et al. 2005, 2007). Oxygen in a redd is consumed by the organic matter and biological communities within the sediments by the geochemical redox processes and by the developing embryos in the eggs (Sear et al, 2014).

High redox potentials of at least 400mV and oxygen concentrations of 6.9 mg/L are accepted as prerequisites for successful development of salmonid eggs and larvae (Sternecker et al., 2013a, 2013b, 2014; Geist & Auerswald, 2007; Armstrong et al., 2003). However, despite severe siltation and apparent impacts to redox potential, electro-fishing data indicates widespread successful reproduction of Atlantic salmon and (less so) brown trout in the Mourne Beg River since the peat slide. It should be noted that fluctuations in our substrata redox measurements may have been caused by photosynthetic activity (and oxygen production) by algae and microbial activity (Sondergaard, 2009), thus understating the true redox potential loss between the water column and river substrata.

The surface cover and silt infiltration rates in the Mourne Beg River upstream control areas (upstream of the Sruhangarve confluence) were considerably lower than downstream (**Figures 3.6 & 3.8**), reflecting the location of these areas upstream of the peat slide impact source. Redd count data for the first spawning season after the peat slide event (December 2020-January 2021) supported the presence and utilisation of now-superior spawning habitat in these upstream areas (see **section 4.1.2** above). Nevertheless, the areas upstream of the Sruhangarve (including the Bunadowen River) were evidently impacted by siltation, albeit from sources other than the peat slide (see section 4.5 for more).

4.3 Influence of peat slide on river hydromorphology (RHAT)

The existing (post peat slide) hydromorphology of the Mourne Beg River, Bunadowen River and Sruhangarve was assessed through the River Hydromorphology Assessment Technique (RHAT) to provide a baseline with which to compare future surveys. No RHAT data was available for the study area before the peat slide event.

It is apparent that the peat slide has had significant negative effects on river hydromorphology in the vicinity of the peat slide, particularly in terms of substrate diversity and condition. Siltation impacts were most evident on the Sruhangarve (origin of peat slide) although severe rates of siltation (up to 95% cover of riverine substrata) were observed >14km downstream of the Sruhangarve confluence.

Nonetheless, the majority of the 40 no. survey sections (*n*=29) were equivalent to **good WFD status** (hydromorph score ≥19.5) (**Figure 3.19**). All 5 no. upstream control sections on the Mourne Beg River (U1-U5), in addition to the Bunadowen survey section (B1), were also equivalent to good WFD status (**Figure 3.19**). This reflected the largely natural river channels with expected channel vegetation (for river type), a lack of barriers to continuity (and fish passage) and good flood plain connectivity. Scores were reduced due to evident heavy siltation (substrate diversity and condition), and to a lesser extent, riparian land use (i.e. agricultural lands, more so in the lower catchment) (**Appendix E**). Only survey section M4 achieved a RHAT score equivalent to **high WFD status.**

The upper survey sections on the Sruhangarve achieved RHAT scores equivalent to **poor WFD status** (S1) and **moderate WFD status** (S2 & S3) due to excessive siltation and impacts on hydromorphology of the channel. However, the lower 1km of the Sruhangarve channel (Sections S4 & S5) were considered of **good WFD status**, despite evident siltation impacts to instream and riparian habitats (**Appendix E; Figure 3.19**).

4.4 Influence of peat slide on biological water quality (macro-invertebrates)

Increases in suspended solids which move over the channel bed within watercourses can affect benthic invertebrates by subjecting them to abrasion and scouring (Bilotta & Brazier, 2008). This can dislodge organisms from the benthos making them more susceptible to predation or can damage exposed respiratory organs of the organisms (Langer, 1980). Increased suspended solids are associated with increases in up or down-channel migration of invertebrates (invertebrate drift), where increases in suspended solids of 40-80mgL^{-1} above background levels causing an increase of invertebrate drift of 25-90% (Gammon, 1970). Increases of suspended solids can also inhibit reattachment to the substratum, encouraging fauna to continue drifting (Suren & Jowett, 2001). Increases in suspended solids can clog feeding structures of filter feeding invertebrates, reducing feeding efficiency, affecting growth rates, which can stress and kill the organisms (Jones et al., 2012). Epilithic periphyton can trap clay-sized particulates reducing its attractiveness for grazing invertebrates (Graham, 1990). Changes in suspended solid concentrations that adversely affect algal growth, biomass, or species composition can impact on populations of grazing invertebrates which rely on periphyton for their energy and nutritional requirements (Newcombe & MacDonald, 1991). Changes in invertebrate abundance as a result of increases in suspended solids have knock-on effects higher up the food chain for example impacting fish, birds and bats that rely on invertebrate prey resources.

Increased fine sediment yield affects macro-invertebrates in many ways, including changing substrate suitability, deteriorating feeding conditions for filter feeders and prey organisms, causing respiratory impacts (lower dissolved oxygen) and increasing drift due to sedimentation or substrate instability (see Hauer et al., 2018 for review). Consequently, increased input of fine sediments leads to a decrease in diversity, abundance, and biomass of macro-invertebrates as well as to a shift in community structure (Leitner et al., 2015, 2021).

Salmonids in Ireland are known to feed primarily on both the larval and adult life stages of Ephemeroptera, Plecoptera and Trichoptera (EPT) taxa and Diptera (de Eyto et al., 2020; Lehane et al., 2001). The percentage EPT ratios were high across all the invertebrate survey stations **(Appendix F)** supporting that there are no significant trends with regards to loss of EPT taxa for foraging salmonids based on the most recent October 2021 survey data. It was, however, clear that the previous December 2020 survey effort illustrated a dominance of Leuctrid mayflies in the samples with a low diversity of mayflies that would support indicate acidification pressures (Feeley et al., 2016). Significant drops in pH likely occurred on the Mourne Beg River and Sruhangarve following the immediate peat slide that had evidently impacted the invertebrate community that would have also been subject to sedimentation and enrichment pressure.

Stonefly species tolerant of acidification were also present within the October 2021 samples (i.e. *Leuctra hippopus* and *Protonemura meyeri*). However, the presence of co-occurrent mayfly species *Ecdyonurus venosus* and *Ecdyonurus dispar* in fair numbers (i.e. species that are highly intolerant of siltation, enrichment and acidification; Kelly-Quinn et al. 2012) indicated evident recovery in the study area. This was also supported by the Q-rating as all of the sampled sites, with exception of the Sruhangarve, achieved the target of good status (≥Q4) requirements of the European Union Environmental Objectives (Surface Waters) (Amendment) Regulations 2019 and the Water Framework Directive (2000/60/EC). While the trend of improving biological water quality is positive, continued biological monitoring would be very beneficial to ensure water quality and associated fisheries status improves. It would also help detect unforeseen impacts associated with resuspension of trapped peat in sink depositional pool that may still impact invertebrate communities in the medium term.

4.5 Other catchment stressors to aquatic ecology

Clearly, the Sruhangarve and Mourne Beg River have been impacted by siltation (colmation) resulting from the Meenbog peat slide of November 2020. However, the available data indicates that there are other factors impacting the system that may act synergistically with the peat slippage event.

Notably, the upper Sruhangarve and Mourne Beg River are bordered by coniferous afforestation, the latter often extending to within <10m of the banktop. Afforestation of catchments is known to impact on the water chemistry of headwater streams, reducing pH and elevating aluminium, ammonia, dissolved organic carbon (DOC), turbidity and eutrophication (phosphorous) (Kelly-Quinn et al., 2016; Harrison et al., 2014), particularly in peat catchments such as the MourneBeg_SC_010 sub-catchment. Low pH is acutely toxic to freshwater fish species and episodic acidic events have a potentially large effect on the distribution of salmonid populations (Serrano, 2005). Eutrophication impacts (e.g. filamentous algal cover of riverine substrata) was observed within the study area during this study and also in the wider catchment during previous surveys (Triturus, 2021). Densities and biomass of juvenile salmonids are known to be significantly lower in watercourses draining afforested catchments and forestry-mediated acidification of streams (water chemistry effects) is a particular threat to Atlantic salmon populations in Ireland (Harrison et al., 2014). This may impact aquatic invertebrate communities and the sensitive developmental stages of salmonids (Finn, 2007; Giller & O'Halloran, 2004).

Additionally, siltation pressures were observed both upstream of the peat impact zone (upper Mourne Beg River and Bunadowen River) and in adjoining Mourne Beg tributaries (outside the zone of impact;

Triturus, 2021). Evidently, afforestation (upper catchment), degraded peatland habitats (upper catchment) and agricultural land use pressures (lower catchment) are contributing to the siltation of the wider catchment, acting synergistically with the peat slide event. Sedimentation of salmonid habitat (the effects of which are outlined in this discussion) is a particular problem in Irish rivers flowing through afforested and agricultural catchments (Evans et al., 2006). Both afforestation and agriculture have been identified as significant threats for the River Finn SAC (002301) (NPWS, 2014), which encompasses the upper Mourne Beg River, as well as the wider River Foyle and Tributaries ASSI (229) (DAERA, 2015).

4.6 Conclusions & recommendations

The primary impacts from the November 2020 peat slide event have occurred regarding salmonid spawning habitat and macro-invertebrate populations, chiefly through siltation (colmation) of riverine substrata. Whilst the decline in riverbed and aquatic habitat quality in the Sruhangarve and Mourne Beg River downstream of the Sruhangarve confluence is likely to impact fish and invert populations in the medium term, partial short-term recovery was evident from the survey results. Biological water quality (macro-invertebrates) has quickly returned (October 2021) to **≥Q4 (good status)** throughout much of the Mourne Beg River study area. However, the peat slide impacts on the Sruhangarve were more severe (closer proximity to peat slide) and the watercourse is likely to take longer to recover (**Q3-4 (moderate status)** in October 2021). Given the spate nature of the Sruhangarve and Mourne Beg River and resulting opportunity for riverine substrata de-colmation (longitudinal resuspension of sediment), the significant influx of fines from the peat slide may flush through the system over time (medium to longer-term).

The continued annual monitoring of fish populations and biological water quality will help elucidate the rate of recovery and assess whether the mitigation measures implemented are working effectively. This will require the cooperation of various agencies and stakeholders.

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6. Appendix A – Life Cycle Unit scores

Table 6.1 Life Cycle Unit scores for salmonid habitat in the *n*=197 survey sections, July 2021 (lower scores = superior habitat)

Section	Watercourse	Spawning	Nursery	Holding	Total score	Habitat value
M1_a	Mourne Beg River	3	3	1	**7**	Good
M1_b	Mourne Beg River	4	3	1	**8**	Good
M1_c	Mourne Beg River	4	3	1	**8**	Good
M1_d	Mourne Beg River	4	3	1	**8**	Good
M1_e	Mourne Beg River	4	2	2	**8**	Good
M2_a	Mourne Beg River	4	3	2	**9**	Moderate
M2_b	Mourne Beg River	3	2	2	**7**	Good
M2_c	Mourne Beg River	4	3	2	**9**	Moderate
M2_d	Mourne Beg River	4	3	2	**9**	Moderate
M2_e	Mourne Beg River	3	3	2	**8**	Good
M3_a	Mourne Beg River	3	3	2	**8**	Good
M3_b	Mourne Beg River	3	3	2	**8**	Good
M3_c	Mourne Beg River	4	3	2	**9**	Moderate
M3_d	Mourne Beg River	4	2	3	**9**	Moderate
M3_e	Mourne Beg River	3	2	2	**7**	Good
M4_a	Mourne Beg River	4	1	3	**8**	Good
M4_b	Mourne Beg River	4	1	4	**9**	Moderate
M4_c	Mourne Beg River	4	1	4	**9**	Moderate
M4_d	Mourne Beg River	4	1	4	**9**	Moderate
M4_e	Mourne Beg River	4	1	4	**9**	Moderate
M5_a	Mourne Beg River	4	1	4	**9**	Moderate
M5_b	Mourne Beg River	4	1	3	**8**	Good
M5_c	Mourne Beg River	4	1	4	**9**	Moderate
M5_d	Mourne Beg River	4	1	4	**9**	Moderate
M5_e	Mourne Beg River	4	1	4	**9**	Moderate
M6_a	Mourne Beg River	4	1	3	**8**	Good
M6_b	Mourne Beg River	4	1	4	**9**	Moderate
M6_c	Mourne Beg River	2	3	1	**6**	Good
M6_d	Mourne Beg River	4	3	2	**9**	Moderate
M6_e	Mourne Beg River	4	1	4	**9**	Moderate
M7_a	Mourne Beg River	3	3	3	**9**	Moderate
M7_b	Mourne Beg River	4	2	4	**10**	Moderate
M7_c	Mourne Beg River	4	2	4	**10**	Moderate
M7_d	Mourne Beg River	3	2	3	**8**	Good
M7_e	Mourne Beg River	3	2	3	**8**	Good
M8_a	Mourne Beg River	3	2	4	**9**	Moderate
M8_b	Mourne Beg River	2	2	2	**6**	Good
M8_c	Mourne Beg River	2	2	2	**6**	Good
M8_d	Mourne Beg River	4	3	2	**9**	Moderate
M8_e	Mourne Beg River	3	4	2	**9**	Moderate
M9_a	Mourne Beg River	3	2	4	**9**	Moderate
M9_b	Mourne Beg River	3	3	2	**8**	Good

Section	Watercourse	Spawning	Nursery	Holding	Total score	Habitat value
M9_c	Mourne Beg River	3	3	2	**8**	Good
M9_d	Mourne Beg River	1	2	3	**6**	Good
M9_e	Mourne Beg River	3	3	3	**9**	Moderate
M10_a	Mourne Beg River	3	2	3	**8**	Good
M10_b	Mourne Beg River	4	2	4	**10**	Moderate
M10_c	Mourne Beg River	4	2	4	**10**	Moderate
M10_d	Mourne Beg River	4	2	3	**9**	Moderate
M10_e	Mourne Beg River	4	2	4	**10**	Moderate
M11_a	Mourne Beg River	4	2	4	**10**	Moderate
M11_b	Mourne Beg River	4	2	3	**9**	Moderate
M11_c	Mourne Beg River	4	2	4	**10**	Moderate
M11_d	Mourne Beg River	4	2	3	**9**	Moderate
M11_e	Mourne Beg River	4	2	4	**10**	Moderate
M12_a	Mourne Beg River	4	2	4	**10**	Moderate
M12_b	Mourne Beg River	4	2	4	**10**	Moderate
M12_c	Mourne Beg River	4	2	4	**10**	Moderate
M12_d	Mourne Beg River	3	2	4	**9**	Moderate
M12_e	Mourne Beg River	4	2	3	**9**	Moderate
M13_a	Mourne Beg River	3	2	3	**8**	Good
M13_b	Mourne Beg River	3	2	3	**8**	Good
M13_c	Mourne Beg River	4	3	3	**10**	Moderate
M13_d	Mourne Beg River	4	3	2	**9**	Moderate
M13_e	Mourne Beg River	3	1	2	**6**	Good
M14_a	Mourne Beg River	4	3	2	**9**	Moderate
M14_b	Mourne Beg River	4	3	2	**9**	Moderate
M14_c	Mourne Beg River	4	2	2	**8**	Good
M14_d	Mourne Beg River	4	2	4	**10**	Moderate
M14_e	Mourne Beg River	4	2	4	**10**	Moderate
M15_a	Mourne Beg River	4	2	4	**10**	Moderate
M15_b	Mourne Beg River	4	2	4	**10**	Moderate
M15_c	Mourne Beg River	4	2	4	**10**	Moderate
M15_d	Mourne Beg River	4	2	3	**9**	Moderate
M15_e	Mourne Beg River	4	1	4	**9**	Moderate
M16_a	Mourne Beg River	4	1	4	**9**	Moderate
M16_b	Mourne Beg River	4	2	4	**10**	Moderate
M16_c	Mourne Beg River	4	2	3	**9**	Moderate
M16_d	Mourne Beg River	3	3	1	**7**	Good
M16_e	Mourne Beg River	4	3	2	**9**	Moderate
M17_a	Mourne Beg River	2	2	2	**6**	Good
M17_b	Mourne Beg River	4	3	1	**8**	Good
M17_c	Mourne Beg River	4	3	1	**8**	Good
M17_d	Mourne Beg River	4	3	1	**8**	Good
M17_e	Mourne Beg River	4	3	1	**8**	Good
M18_a	Mourne Beg River	4	3	1	**8**	Good
M18_b	Mourne Beg River	4	3	1	**8**	Good

Section	Watercourse	Spawning	Nursery	Holding	Total score	Habitat value
M18_c	Mourne Beg River	4	2	2	**8**	Good
M18_d	Mourne Beg River	4	2	2	**8**	Good
M18_e	Mourne Beg River	4	3	1	**8**	Good
M19_a	Mourne Beg River	4	3	1	**8**	Good
M19_b	Mourne Beg River	4	2	4	**10**	Moderate
M19_c	Mourne Beg River	4	2	4	**10**	Moderate
M19_d	Mourne Beg River	4	2	4	**10**	Moderate
M19_e	Mourne Beg River	4	2	3	**9**	Moderate
M20_a	Mourne Beg River	4	2	4	**10**	Moderate
M20_b	Mourne Beg River	4	2	4	**10**	Moderate
M20_c	Mourne Beg River	4	2	2	**8**	Good
M20_d	Mourne Beg River	4	1	2	**7**	Good
M20_e	Mourne Beg River	4	2	3	**9**	Moderate
M21_a	Mourne Beg River	4	2	3	**9**	Moderate
M21_b	Mourne Beg River	4	2	2	**8**	Good
M21_c	Mourne Beg River	4	1	4	**9**	Moderate
M21_d	Mourne Beg River	3	2	3	**8**	Good
M21_e	Mourne Beg River	3	1	1	**5**	Excellent
M22_a	Mourne Beg River	4	3	1	**8**	Good
M22_b	Mourne Beg River	4	3	1	**8**	Good
M22_c	Mourne Beg River	4	3	1	**8**	Good
M22_d	Mourne Beg River	4	3	1	**8**	Good
M22_e	Mourne Beg River	4	3	1	**8**	Good
M23_a	Mourne Beg River	4	3	1	**8**	Good
M23_b	Mourne Beg River	4	2	3	**9**	Moderate
M23_c	Mourne Beg River	4	2	2	**8**	Good
M23_d	Mourne Beg River	4	1	3	**8**	Good
M23_e	Mourne Beg River	4	1	3	**8**	Good
M24_a	Mourne Beg River	4	2	2	**8**	Good
M24_b	Mourne Beg River	4	3	1	**8**	Good
M24_c	Mourne Beg River	4	3	1	**8**	Good
M24_d	Mourne Beg River	4	3	1	**8**	Good
M24_e	Mourne Beg River	4	3	1	**8**	Good
M25_a	Mourne Beg River	4	3	1	**8**	Good
M25_b	Mourne Beg River	4	3	1	**8**	Good
M25_c	Mourne Beg River	4	3	2	**9**	Moderate
M25_d	Mourne Beg River	4	2	3	**9**	Moderate
M25_e	Mourne Beg River	4	1	4	**9**	Moderate
M26_a	Mourne Beg River	4	1	4	**9**	Moderate
M26_b	Mourne Beg River	4	1	4	**9**	Moderate
M26_c	Mourne Beg River	4	1	4	**9**	Moderate
M26_d	Mourne Beg River	4	3	2	**9**	Moderate
M26_e	Mourne Beg River	4	3	3	**10**	Moderate
M27_a	Mourne Beg River	2	3	2	**7**	Good
M27_b	Mourne Beg River	2	2	3	**7**	Good

Section	Watercourse	Spawning	Nursery	Holding	Total score	Habitat value
M27_c	Mourne Beg River	3	2	3	**8**	Good
M27_d	Mourne Beg River	4	3	1	**8**	Good
M27_e	Mourne Beg River	3	3	2	**8**	Good
M28_a	Mourne Beg River	4	3	1	**8**	Good
M28_b	Mourne Beg River	4	3	1	**8**	Good
M28_c	Mourne Beg River	4	3	1	**8**	Good
M28_d	Mourne Beg River	3	3	3	**9**	Moderate
M28_e	Mourne Beg River	4	3	1	**8**	Good
M29_a	Mourne Beg River	4	3	1	**8**	Good
M29_b	Mourne Beg River	4	3	1	**8**	Good
M29_c	Mourne Beg River	4	3	1	**8**	Good
M29_d	Mourne Beg River	4	3	2	**9**	Moderate
S1_a	Sruhangarve	4	3	3	**10**	Moderate
S1_b	Sruhangarve	4	3	3	**10**	Moderate
S1_c	Sruhangarve	4	3	3	**10**	Moderate
S1_d	Sruhangarve	4	3	3	**10**	Moderate
S1_e	Sruhangarve	4	3	3	**10**	Moderate
S2_a	Sruhangarve	4	4	2	**10**	Moderate
S2_b	Sruhangarve	4	3	2	**9**	Moderate
S2_c	Sruhangarve	4	2	3	**9**	Moderate
S2_d	Sruhangarve	4	2	2	**8**	Good
S2_e	Sruhangarve	4	2	2	**8**	Good
S3_a	Sruhangarve	4	2	2	**8**	Good
S3_b	Sruhangarve	4	4	2	**10**	Moderate
S3_c	Sruhangarve	3	2	2	**7**	Good
S3_d	Sruhangarve	3	2	2	**7**	Good
S3_e	Sruhangarve	4	2	2	**8**	Good
S4_a	Sruhangarve	4	2	2	**8**	Good
S4_b	Sruhangarve	4	2	2	**8**	Good
S4_c	Sruhangarve	4	2	2	**8**	Good
S4_d	Sruhangarve	4	3	3	**10**	Moderate
S4_e	Sruhangarve	4	2	2	**8**	Good
S5_a	Sruhangarve	3	2	2	**7**	Good
S5_b	Sruhangarve	4	3	2	**9**	Moderate
S5_c	Sruhangarve	3	3	2	**8**	Good
S5_d	Sruhangarve	4	4	2	**10**	Moderate
S5_e	Sruhangarve	4	4	2	**10**	Moderate
U1_a	Mourne Beg River	1	2	3	**6**	Good
U1_b	Mourne Beg River	3	3	1	**7**	Good
U1_c	Mourne Beg River	2	3	2	**7**	Good
U1_d	Mourne Beg River	3	3	2	**8**	Good
U1_e	Mourne Beg River	2	2	2	**6**	Good
U1_f	Mourne Beg River	2	2	3	**7**	Good
U2_a	Mourne Beg River	2	2	4	**8**	Good
U2_b	Mourne Beg River	3	2	3	**8**	Good

Triturus

Section	Watercourse	Spawning	Nursery	Holding	Total score	Habitat value
U2_c	Mourne Beg River	2	3	3	**8**	Good
U2_d	Mourne Beg River	2	2	2	**6**	Good
U2_e	Mourne Beg River	3	2	2	**7**	Good
U2_f	Mourne Beg River	2	2	3	**7**	Good
U3_a	Mourne Beg River	2	2	2	**6**	Good
U3_b	Mourne Beg River	4	2	1	**7**	Good
U3_c	Mourne Beg River	4	2	4	**10**	Moderate
U3_d	Mourne Beg River	4	2	3	**9**	Moderate
U3_e	Mourne Beg River	4	2	2	**8**	Good
U4_a	Mourne Beg River	4	2	2	**8**	Good
U4_b	Mourne Beg River	4	2	2	**8**	Good
U4_c	Mourne Beg River	4	3	2	**9**	Moderate
U4_d	Mourne Beg River	4	2	2	**8**	Good
U4_e	Mourne Beg River	4	2	2	**8**	Good
U5_a	Mourne Beg River	2	2	2	**6**	Good
U5_b	Mourne Beg River	3	3	1	**7**	Good
U5_c	Mourne Beg River	3	2	1	**6**	Good
B1_a	Bunadowen River	4	2	1	**7**	Good
B1_b	Bunadowen River	3	2	3	**8**	Good
B1_c	Bunadowen River	2	2	2	**6**	Good

7. Appendix B – annual spawning redd distribution

Note: data not available for the Mourne Beg River in the 2013-14 period

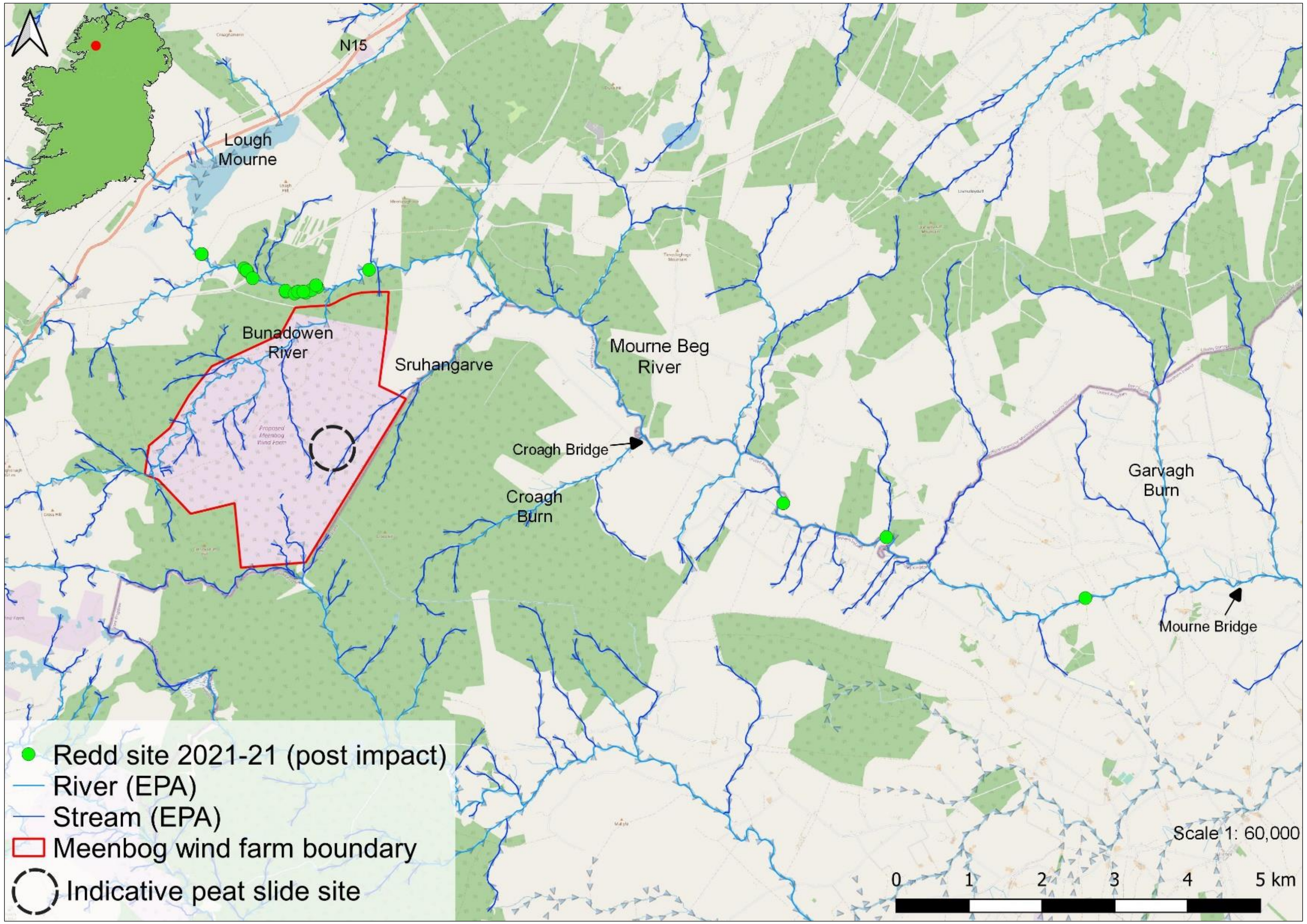

Figure 7.1 Distribution of salmonid spawning redds on the Mourne Beg River 2020-21 (source: Loughs Agency)

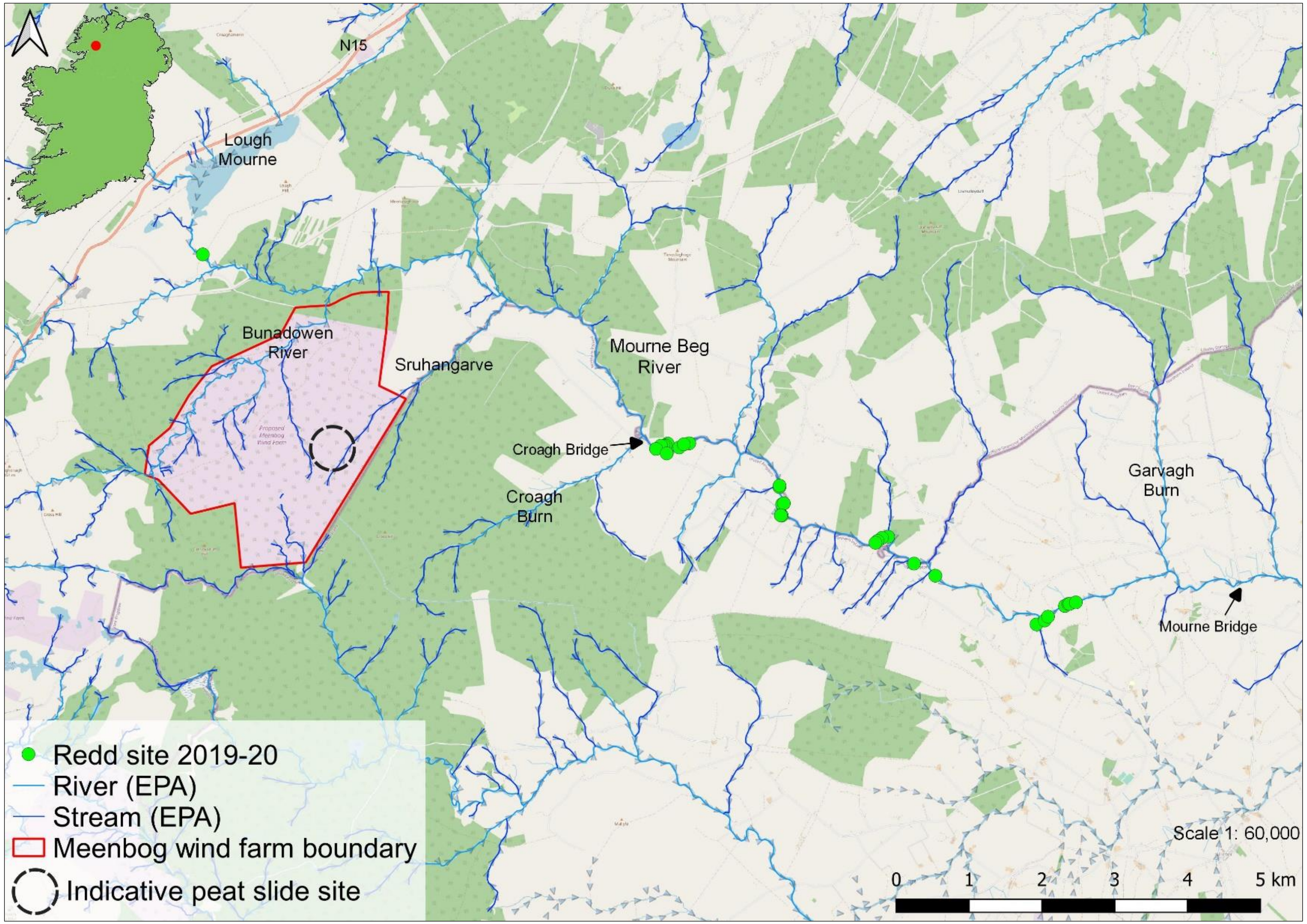

Figure 7.2 Distribution of salmonid spawning redds on the Mourne Beg River 2019-20 (source: Loughs Agency)

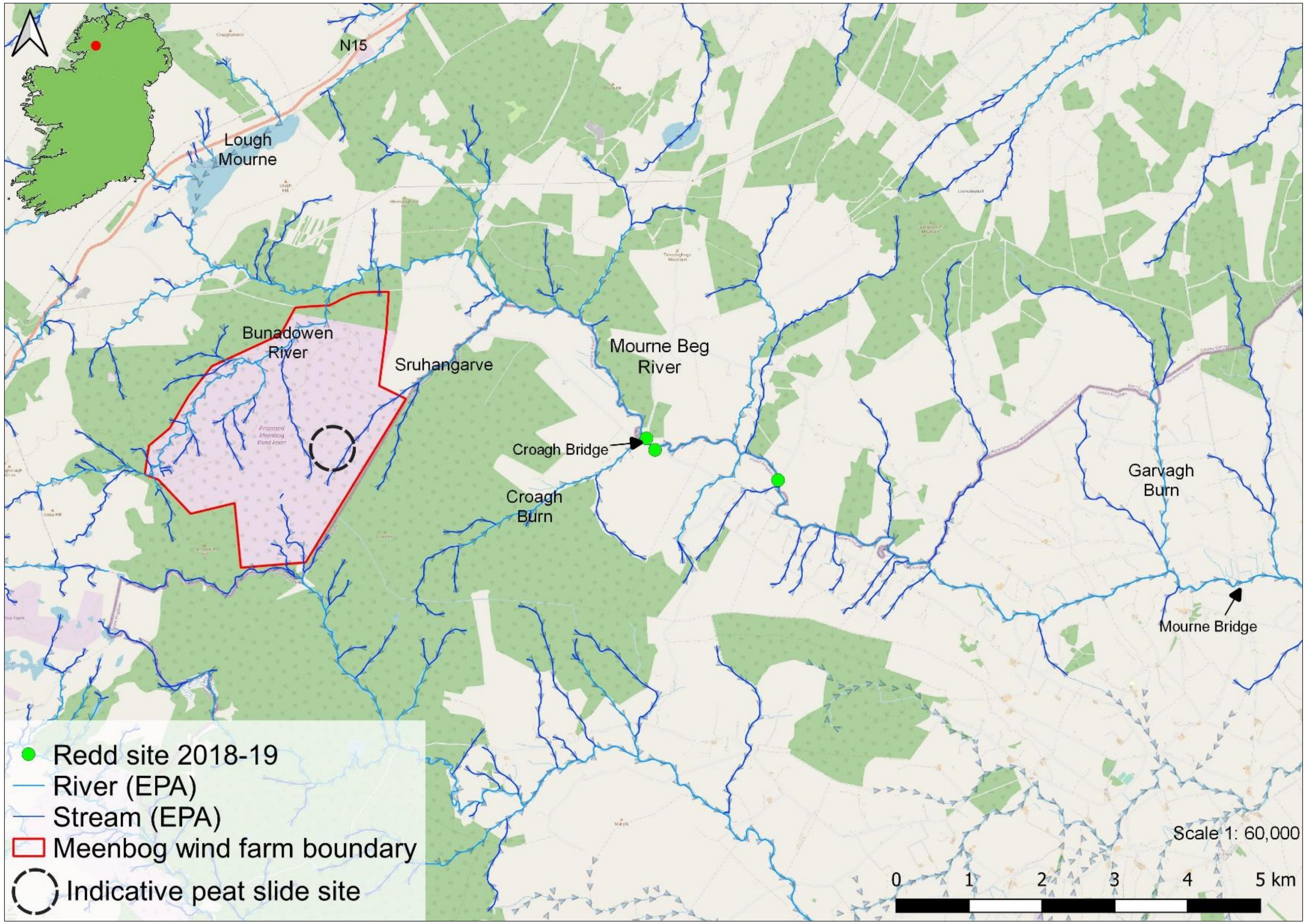

Figure 7.3 Distribution of salmonid spawning redds on the Mourne Beg River 2018-19 (source: Loughs Agency)

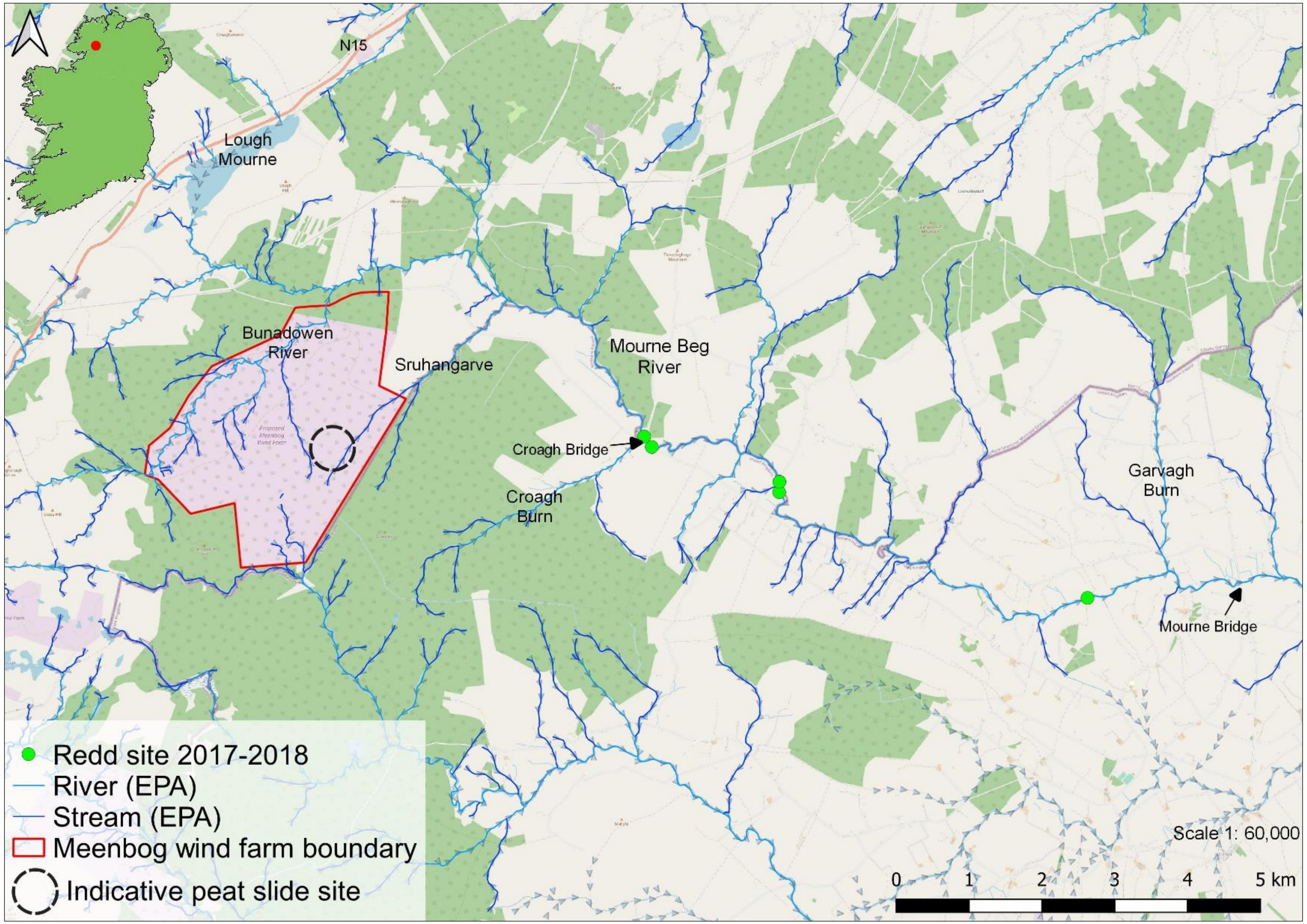

Figure 7.4 Distribution of salmonid spawning redds on the Mourne Beg River 2017-18 (source: Loughs Agency)

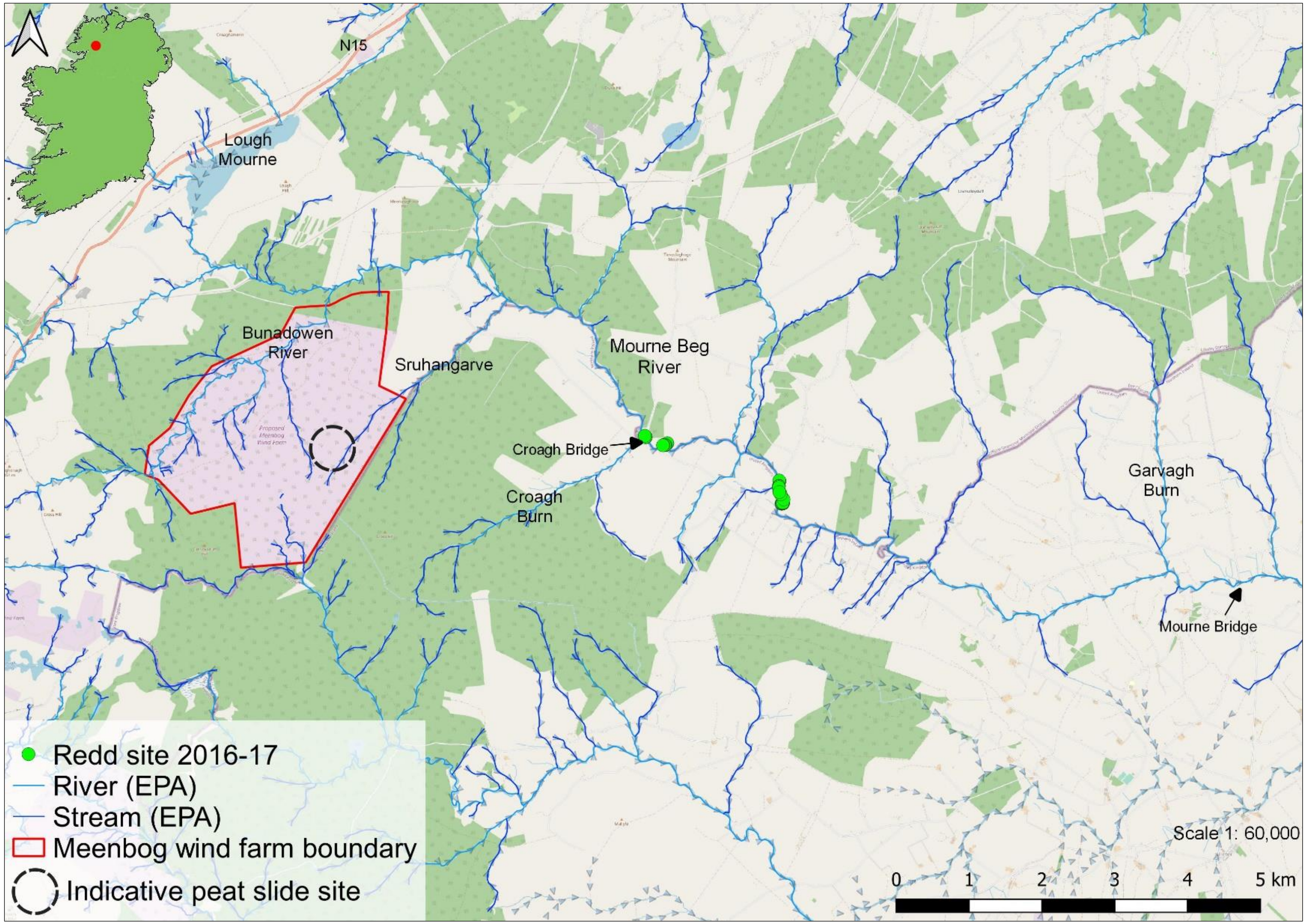

Figure 7.5 Distribution of salmonid spawning redds on the Mourne Beg River 2016-17 (source: Loughs Agency)

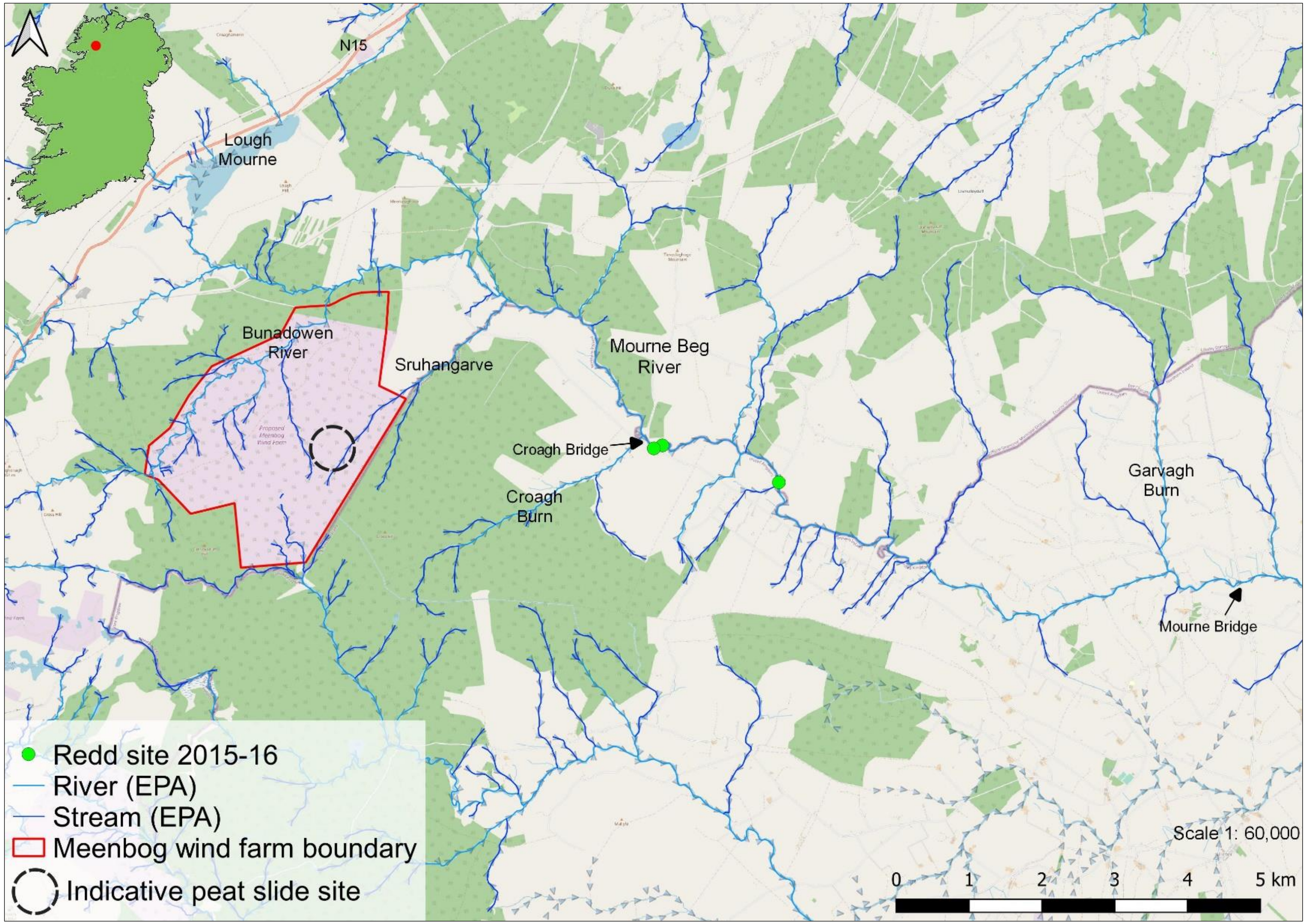

Figure 7.6 Distribution of salmonid spawning redds on the Mourne Beg River 2015-16 (source: Loughs Agency)

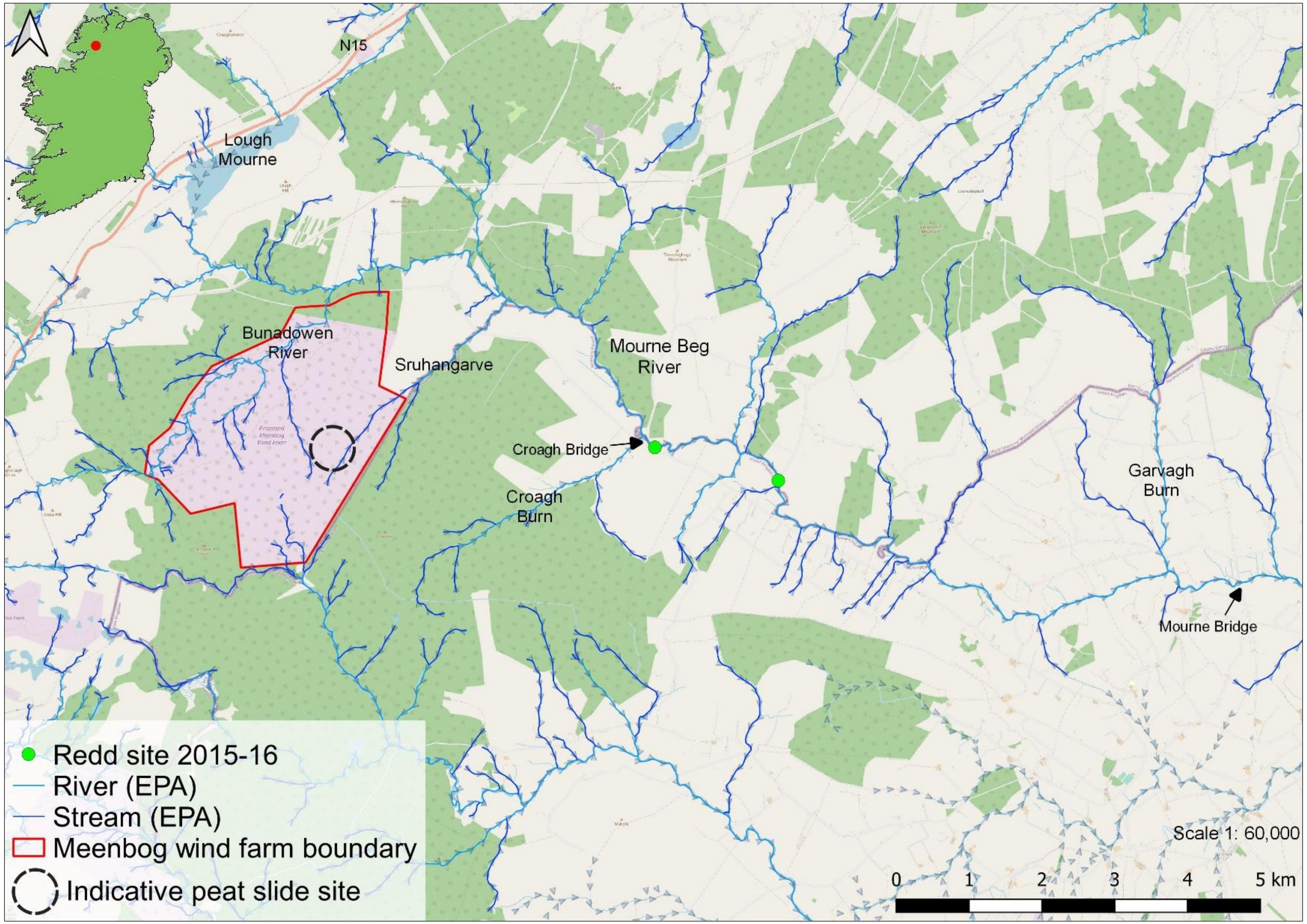

Figure 7.7 Distribution of salmonid spawning redds on the Mourne Beg River 2014-15 (source: Loughs Agency)

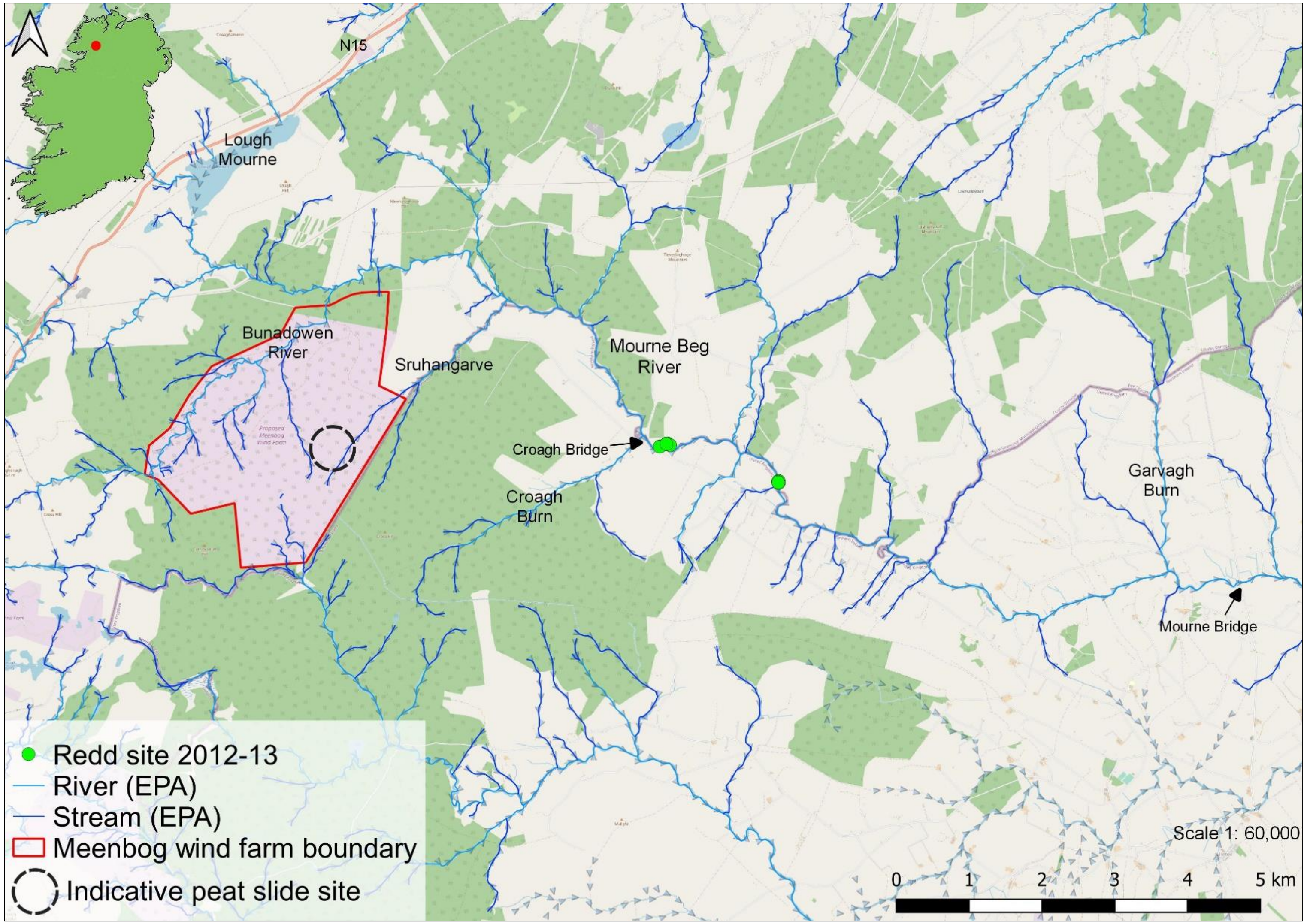

Figure 7.8 Distribution of salmonid spawning redds on the Mourne Beg River 2012-13 (source: Loughs Agency)

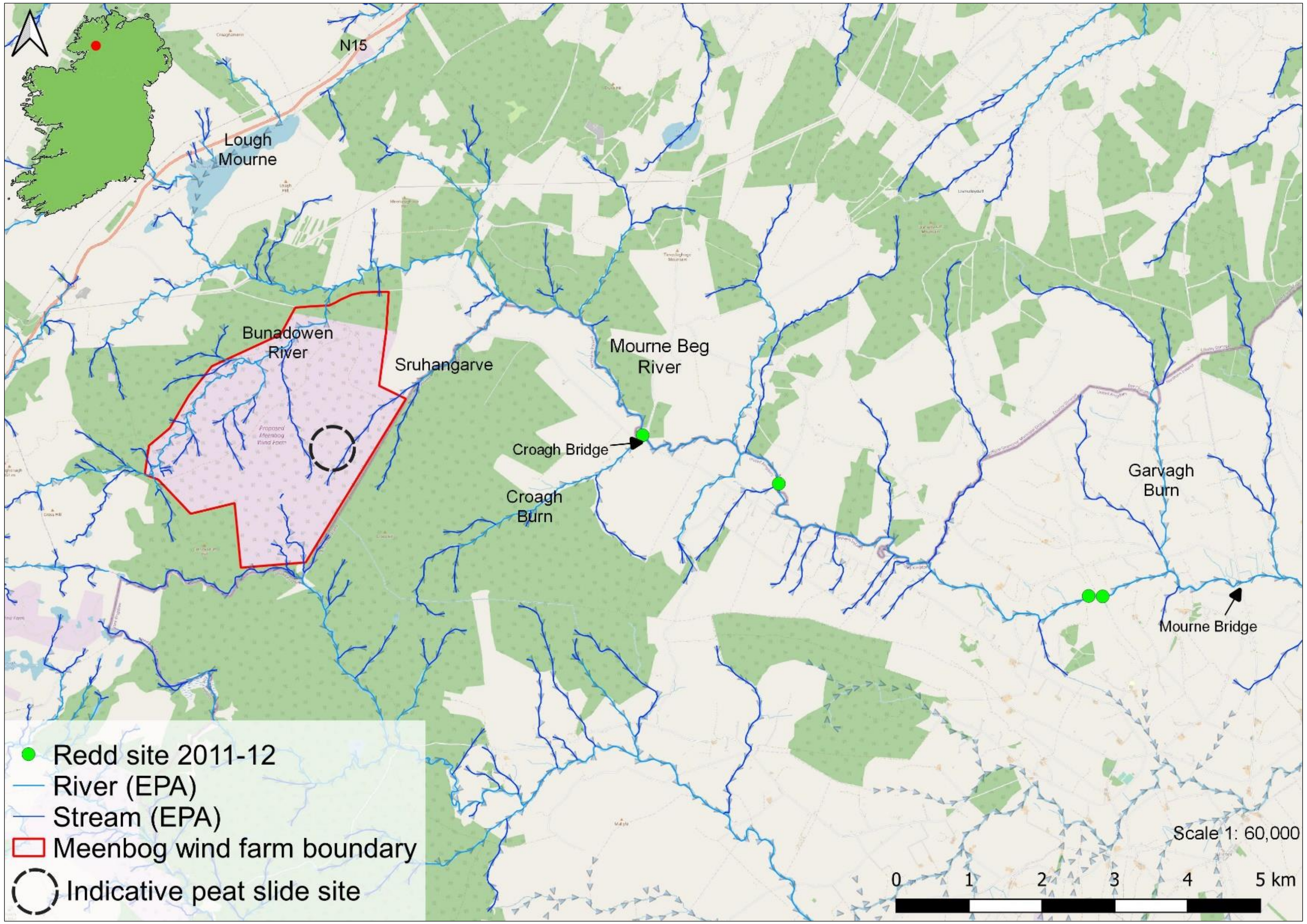

Figure 7.9 Distribution of salmonid spawning redds on the Mourne Beg River 2011-12 (source: Loughs Agency)

8. Appendix C – redox measurements

Table 8.1 Redox readings for the *n*=80 survey locations, July 2021. Greyed out values indicate sites where substrata readings were not possible due to compacted/bedrock substrata

			Water column (mV)				Substrata (mV) (5cm depth)				
Watercourse	**Section**	**Sample ID**	**Reading 1**	**Reading 2**	**Reading 3**	**Mean**	**Reading 1**	**Reading 2**	**Reading 3**	**Mean**	**% loss**
Mourne Beg River	U1	Redox_U1_a	359	369	347	**358**	352	362	333	**349**	-3%
Mourne Beg River	U1	Redox_U1_b	289	302	349	**313**	249	272	340	**287**	-8%
Mourne Beg River	U2	Redox_U2_a	303	291	294	**296**	249	229	263	**247**	-17%
Mourne Beg River	U2	Redox_U2_b	323	312	334	**323**	302	230	249	**260**	-19%
Mourne Beg River	U3	Redox_U3_a	184	225	220	**210**	277	108	291	**225**	7%
Mourne Beg River	U3	Redox_U3_b	256	280	208	**248**	254	295	307	**285**	15%
Mourne Beg River	U4	Redox_U4_a	279	290	289	**286**	305	300	334	**313**	9%
Mourne Beg River	U4	Redox_U4_b	275	272	272	**273**	297	356	325	**326**	19%
Mourne Beg River	U5	Redox_U5_a	255	243	263	**254**	317	333	326	**325**	28%
Mourne Beg River	M1	Redox_M1_a	322	317	334	**324**	255	302	256	**271**	-16%
Mourne Beg River	M1	Redox_M1_b	287	290	279	**285**	307	311	323	**314**	10%
Mourne Beg River	M2	Redox_M2_a	371	322	327	**340**	272	258	304	**278**	-18%
Mourne Beg River	M2	Redox_M2_b	261	312	323	**299**	226	292	265	**261**	-13%
Mourne Beg River	M3	Redox_M3_a	285	326	323	**311**	281	256	292	**276**	-11%
Mourne Beg River	M3	Redox_M3_b	305	352	362	**340**	264	287	315	**289**	-15%
Mourne Beg River	M4	Redox_M4_a	340	346	330	**339**	302	257	285	**281**	-17%
Mourne Beg River	M4	Redox_M4_b	330	325	347	**334**	286	250	314	**283**	-15%
Mourne Beg River	M5	Redox_M5_a	352	322	323	**332**	252	231	223	**235**	-29%
Mourne Beg River	M5	Redox_M5_b	316	226	321	**288**	276	328	301	**302**	5%
Mourne Beg River	M6	Redox_M6_a	326	316	330	**324**	288	302	302	**297**	-8%
Mourne Beg River	M6	Redox_M6_b	327	316	348	**330**	274	360	277	**304**	-8%
Mourne Beg River	M7	Redox_M7_a	324	210	327	**287**	296	283	278	**286**	0%
Mourne Beg River	M7	Redox_M7_b	292	305	339	**312**	255	286	245	**262**	-16%
Mourne Beg River	M8	Redox_M8_a	306	340	323	**323**	308	270	305	**294**	-9%
Mourne Beg River	M8	Redox_M8_b	319	301	309	**310**	283	265	293	**280**	-9%

			Water column (mV)				Substrata (mV) (5cm depth)				
Watercourse	Section	Sample ID	Reading 1	Reading 2	Reading 3	Mean	Reading 1	Reading 2	Reading 3	Mean	% loss
Mourne Beg River	M9	Redox_M9_a	356	331	366	**351**	313	313	333	**320**	-9%
Mourne Beg River	M9	Redox_M9_b	336	327	316	**326**	292	284	290	**289**	-12%
Mourne Beg River	M10	Redox_M10_a	326	320	351	**332**	302	282	325	**303**	-9%
Mourne Beg River	M10	Redox_M10_b	329	341	332	**334**	236	300	314	**283**	-15%
Mourne Beg River	M11	Redox_M11_a	309	336	351	**332**	263	284	299	**282**	-15%
Mourne Beg River	M11	Redox_M11_b	314	333	282	**310**	273	304	266	**281**	-9%
Mourne Beg River	M12	Redox_M12_a	327	318	365	**337**	290	298	262	**283**	-16%
Mourne Beg River	M12	Redox_M12_b	282	212	347	**280**	218	313	280	**270**	-4%
Mourne Beg River	M13	Redox_M13_a	331	355	333	**340**	310	274	281	**288**	-15%
Mourne Beg River	M13	Redox_M13_b	326	353	360	**346**	282	279	286	**282**	-18%
Mourne Beg River	M14	Redox_M14_a	356	347	351	**351**	252	310	292	**285**	-19%
Mourne Beg River	M14	Redox_M14_b	283	286	203	**257**	248	251	265	**255**	-1%
Mourne Beg River	M15	Redox_M15_a	348	314	358	**340**	278	281	335	**298**	-12%
Mourne Beg River	M15	Redox_M15_b	296	305	n/a	**301**	274	256	n/a	**265**	-12%
Mourne Beg River	M16	Redox_M16_a	343	348	n/a	**346**	291	268	n/a	**280**	-19%
Mourne Beg River	M16	Redox_M16_b	328	304	n/a	**316**	281	269	n/a	**275**	-13%
Mourne Beg River	M17	Redox_M17_a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Mourne Beg River	M17	Redox_M17_b	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Mourne Beg River	M18	Redox_M18_a	310	296	349	**318**	265	259	274	**266**	-16%
Mourne Beg River	M18	Redox_M18_b	351	307	356	**338**	258	262	259	**260**	-23%
Mourne Beg River	M19	Redox_M19_a	331	314	229	**291**	285	215	280	**260**	-11%
Mourne Beg River	M19	Redox_M19_b	336	331	n/a	**334**	272	280	n/a	**276**	-17%
Mourne Beg River	M20	Redox_M20_a	357	346	335	**346**	304	272	303	**293**	-15%
Mourne Beg River	M20	Redox_M20_b	317	354	348	**340**	214	272	267	**251**	-26%
Mourne Beg River	M21	Redox_M21_a	355	341	n/a	**348**	271	263	n/a	**267**	-23%
Mourne Beg River	M21	Redox_M21_b	347	365	251	**321**	268	284	271	**274**	-15%
Mourne Beg River	M22	Redox_M22_a	361	371	368	**367**	275	282	280	**279**	-24%
Mourne Beg River	M22	Redox_M22_b	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

			Water column (mV)				Substrata (mV) (5cm depth)				
Watercourse	Section	Sample ID	Reading 1	Reading 2	Reading 3	Mean	Reading 1	Reading 2	Reading 3	Mean	% loss
Mourne Beg River	M23	Redox_M23_a	327	330	319	**325**	251	253	239	**248**	-24%
Mourne Beg River	M23	Redox_M23_b	334	358	371	**354**	288	287	253	**276**	-22%
Mourne Beg River	M24	Redox_M24_a	319	351	360	**343**	294	264	274	**277**	-19%
Mourne Beg River	M24	Redox_M24_b	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Mourne Beg River	M25	Redox_M25_a	322	330	325	**326**	230	224	221	**225**	-31%
Mourne Beg River	M25	Redox_M25_b	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Mourne Beg River	M26	Redox_M26_a	292	295	274	**287**	264	267	255	**262**	-9%
Mourne Beg River	M26	Redox_M26_b	296	295	299	**297**	269	271	269	**270**	-9%
Mourne Beg River	M27	Redox_M27_a	302	330	322	**318**	255	221	233	**236**	-26%
Mourne Beg River	M27	Redox_M27_b	327	329	333	**330**	309	299	283	**297**	-10%
Mourne Beg River	M28	Redox_M28_a	314	325	n/a	**320**	273	270	n/a	**272**	-15%
Mourne Beg River	M28	Redox_M28_b	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Mourne Beg River	M29	Redox_M29_a	310	343	358	**337**	241	296	261	**266**	-21%
Bunadowen River	B1	Redox_B1_a	326	337	284	**316**	299	305	277	**294**	-7%
Sruhangarve	S1	Redox_S1_a	252	260	283	**265**	171	153	305	**210**	-21%
Sruhangarve	S1	Redox_S1_b	241	268	247	**252**	248	292	272	**271**	7%
Sruhangarve	S1	Redox_S1_c	252	224	260	**245**	138	94	141	**124**	-49%
Sruhangarve	S1	Redox_S1_d	229	213	n/a	**221**	168	89	n/a	**129**	-42%
Sruhangarve	S2	Redox_S2_a	297	298	297	**297**	277	369	276	**307**	3%
Sruhangarve	S2	Redox_S2_b	239	235	236	**237**	217	89	91	**132**	-44%
Sruhangarve	S3	Redox_S3_a	244	292	280	**272**	152	254	280	**229**	-16%
Sruhangarve	S3	Redox_S3_b	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Sruhangarve	S4	Redox_S4_a	322	331	344	**332**	277	270	254	**267**	-20%
Sruhangarve	S4	Redox_S4_b	275	252	269	**265**	340	358	324	**341**	28%
Sruhangarve	S5	Redox_S5_a	229	270	286	**262**	160	150	170	**160**	-39%
Sruhangarve	S5	Redox_S5_b	265	274	382	**307**	277	290	312	**293**	-5%

9. Appendix D – siltation % cover & silt infiltration

Table 9.1 % silt cover and silt infiltration (to 5cm substrate depth) on the Mourne Beg River, Sruhangarve and Bunadowen River, June 2021 (following Moorkens & Killeen, 2020)

Replicate	Watercourse	Sediment character	% surface cover	Severity	Silt infiltration
U1_a	Mourne Beg River (u/s Sruhangarve)	Silt & peat	5%	Slight	Slight
U1_b	Mourne Beg River (u/s Sruhangarve)	Silt & peat	5%	Slight	Slight
U2_a	Mourne Beg River (u/s Sruhangarve)	Silt & peat	5%	Slight	Slight
U2_b	Mourne Beg River (u/s Sruhangarve)	Silt & peat	5%	Slight	Slight
U3_a	Mourne Beg River (u/s Sruhangarve)	Silt & peat	5%	Slight	Slight
U3_b	Mourne Beg River (u/s Sruhangarve)	Silt & peat	5%	Slight	Slight
U4_a	Mourne Beg River (u/s Sruhangarve)	Silt & peat	5%	Slight	Slight
U4_b	Mourne Beg River (u/s Sruhangarve)	Silt & peat	5%	Slight	Slight
U5_a	Mourne Beg River (u/s Sruhangarve)	Silt & peat	5%	Slight	Slight
U5_b	Mourne Beg River (u/s Sruhangarve)	Silt & peat	5%	Slight	Slight
M1_a	Mourne Beg River	Floc & peat	65%	Severe	Severe
M1_b	Mourne Beg River	Floc & peat	75%	Severe	Severe
M2_a	Mourne Beg River	Floc & peat	60%	Severe	Severe
M2_b	Mourne Beg River	Floc & peat	50%	Severe	Severe
M3_a	Mourne Beg River	Floc & peat	60%	Severe	Severe
M3_b	Mourne Beg River	Floc & peat	50%	Severe	Severe
M4_a	Mourne Beg River	Floc & peat	40%	Severe	Severe
M4_b	Mourne Beg River	Floc & peat	20%	Moderate	Moderate
M5_a	Mourne Beg River	Floc & peat	40%	Severe	Severe
M5_b	Mourne Beg River	Floc & peat	40%	Severe	Severe
M6_a	Mourne Beg River	Floc & peat	50%	Severe	Severe
M6_b	Mourne Beg River	Floc & peat	50%	Severe	Severe
M7_a	Mourne Beg River	Floc & peat	90%	Severe	Severe
M7_a	Mourne Beg River	Floc & peat	90%	Severe	Severe
M8_a	Mourne Beg River	Floc & peat	90%	Severe	Severe
M8_b	Mourne Beg River	Floc & peat	90%	Severe	Severe
M9_a	Mourne Beg River	Floc & peat	90%	Severe	Severe
M9_b	Mourne Beg River	Floc & peat	90%	Severe	Severe
M10_a	Mourne Beg River	Floc & peat	90%	Severe	Severe
M10_b	Mourne Beg River	Floc & peat	90%	Severe	Severe
M11_a	Mourne Beg River	Floc & peat	90%	Severe	Severe
M11_b	Mourne Beg River	Floc & peat	90%	Severe	Severe
M12_a	Mourne Beg River	Floc & peat	90%	Severe	Severe
M12_b	Mourne Beg River	Floc & peat	90%	Severe	Severe
M13_a	Mourne Beg River	Floc & peat	90%	Severe	Severe
M13_b	Mourne Beg River	Floc & peat	90%	Severe	Severe
M14_a	Mourne Beg River	Floc & peat	90%	Severe	Severe
M14_b	Mourne Beg River	Floc & peat	90%	Severe	Severe
M15_a	Mourne Beg River	Floc & peat	90%	Severe	Severe
M15_b	Mourne Beg River	Floc & peat	90%	Severe	Severe
M16_a	Mourne Beg River	Floc & peat	90%	Severe	Severe
M16_b	Mourne Beg River	Floc & peat	90%	Severe	Severe

Replicate	Watercourse	Sediment character	% surface cover	Severity	Silt infiltration
M17_a	Mourne Beg River	Floc & peat	95%	Severe	Severe
M17_b	Mourne Beg River	Floc & peat	95%	Severe	Severe
M18_a	Mourne Beg River	Floc & peat	90%	Severe	Severe
M18_b	Mourne Beg River	Floc & peat	90%	Severe	Severe
M19_a	Mourne Beg River	Floc & peat	20%	Moderate	Slight
M19_b	Mourne Beg River	Floc & peat	20%	Moderate	Slight
M20_a	Mourne Beg River	Floc & peat	30%	Moderate	Moderate
M20_b	Mourne Beg River	Floc & peat	30%	Moderate	Moderate
M21_a	Mourne Beg River	Bedrock	0%	None	None
M21_b	Mourne Beg River	Floc & peat	80%	Severe	Severe
M22_a	Mourne Beg River	Floc & silt	80%	Severe	Severe
M23_a	Mourne Beg River	Floc & silt	50%	Severe	Severe
M24_a	Mourne Beg River	Floc & peat	90%	Severe	Severe
M25_a	Mourne Beg River	Floc & peat	10%	Moderate	Slight
M26_a	Mourne Beg River	Floc	25%	Moderate	Slight
M27_a	Mourne Beg River	Floc	80%	Severe	Severe
M28_a	Mourne Beg River	Floc & peat	70%	Severe	Severe
M29_a	Mourne Beg River	Floc & peat	70%	Severe	Severe
B1_a	Bunadowen River	Silt & peat	5%	Slight	Slight
B1_b	Bunadowen River	Silt & peat	5%	Slight	Slight
S1_a	Sruhangarve	Peat & floc	80%	Severe	Severe
S2_a	Sruhangarve	Peat & floc	90%	Severe	Severe
S3_a	Sruhangarve	Peat & floc	30%	Severe	Severe
S4_a	Sruhangarve	Peat & floc	25%	Moderate	Moderate
S5_a	Sruhangarve	Peat & floc	100%	Severe	Severe

10. Appendix E – RHAT scores

Table 10.1 River Habitat Assessment Technique (RHAT) scores for the *n*=40 survey sections, July 2021 (after Murphy & Toland, 2014)

Watercourse	Section	Channel morphology	Channel vegetation	Substrate condition	Barriers	Bank structure & stability	Bank vegetation	Riparian land use	Floodplain interactions	Total score	Hydromorph score	WFD status
Bunadowen River	**B1**	3.5	2.5	3.5	3.5	3	1	0	4	**21**	0.7	Good
Mourne Beg River	**U1**	4	2.5	3	4	3.5	2	1.5	4	**24.5**	0.8	Good
Mourne Beg River	**U2**	4	2.5	3	4	3.5	2	1.5	4	**24.5**	0.8	Good
Mourne Beg River	**U3**	3	2.5	3.5	3.5	3	1.5	2	4	**23**	0.7	Good
Mourne Beg River	**U4**	4	2.5	3.5	4	3	2	3	4	**26**	0.8	Good
Mourne Beg River	**U5**	4	2.5	3.5	4	3	1.5	2	4	**24.5**	0.8	Good
Sruhangarve	**S1**	1	1	0	0	0	1	1	4	**8**	0.3	Poor
Sruhangarve	**S2**	4	2	0	4	1	1.5	0.5	4	**17**	0.5	Moderate
Sruhangarve	**S3**	4	2	0	4	1	1.5	0.5	4	**17**	0.5	Mod
Sruhangarve	**S4**	4	2.5	2	4	3	2	2	4	**23.5**	0.7	Good
Sruhangarve	**S5**	4	1	0	4	3	2	2	4	**20**	0.6	Good
Mourne Beg River	**M1**	4	2	2	4	4	2.5	1.5	4	**24**	0.8	Good
Mourne Beg River	**M2**	4	2	2	4	4	3	2.5	4	**25.5**	0.8	Good
Mourne Beg River	**M3**	4	2	2	4	4	3	2.5	4	**25.5**	0.8	Good
Mourne Beg River	**M4**	4	2.5	3	4	4	3	1.5	4	**26**	0.8	High
Mourne Beg River	**M5**	4	2.5	2	4	4	3	1.5	4	**25**	0.8	Good
Mourne Beg River	**M6**	4	2.5	2	4	4	3	1.5	4	**25**	0.8	Good
Mourne Beg River	**M7**	4	2	1	4	4	3	1.5	4	**23.5**	0.7	Good
Mourne Beg River	**M8**	3	2	1	4	3	1	1	3	**18**	0.6	Mod
Mourne Beg River	**M9**	4	2	1	4	3	1	2	4	**21**	0.7	Good
Mourne Beg River	**M10**	4	2	1	4	3	2	1.5	4	**21.5**	0.7	Good
Mourne Beg River	**M11**	4	2	1	4	3	2	2	4	**22**	0.7	Good
Mourne Beg River	**M12**	4	2	1	4	3	2	2	4	**22**	0.7	Good
Mourne Beg River	**M13**	2	2	1	4	3	3	1.5	3	**19.5**	0.6	Good
Mourne Beg River	**M14**	2	2	1	4	3	3	1.5	3	**19.5**	0.6	Good
Mourne Beg River	**M15**	4	2	1	4	3	2	1.5	4	**21.5**	0.7	Good

Watercourse	Section	Channel morphology	Channel vegetation	Substrate condition	Barriers	Bank structure & stability	Bank vegetation	Riparian land use	Floodplain interactions	Total score	Hydromorph score	WFD status
Mourne Beg River	**M16**	4	2	1	4	3	2	1.5	4	**21.5**	0.7	Good
Mourne Beg River	**M17**	0	0	0	4	1	2.5	1	2	**10.5**	0.3	Poor
Mourne Beg River	**M18**	1	1	0.5	4	2	1.5	1.5	2	**13.5**	0.4	Poor
Mourne Beg River	**M19**	3.5	2	2	4	3	3	2	2	**21.5**	0.7	Good
Mourne Beg River	**M20**	1	3	2	1	3	3	3	3	**19**	0.6	Moderate
Mourne Beg River	**M21**	3	3	2	1	3	3	2.5	1.5	**19**	0.6	Moderate
Mourne Beg River	**M22**	3	2	2	4	3	3	1	2	**20**	0.6	Good
Mourne Beg River	**M23**	3	3	2	4	2.5	3	2	2	**21.5**	0.7	Good
Mourne Beg River	**M24**	1	1	1	4	2.5	2	1	2	**14.5**	0.5	Moderate
Mourne Beg River	**M25**	3	2.5	2	4	3	3.5	1	3	**22**	0.7	Good
Mourne Beg River	**M26**	3	3	2	4	2.5	3	2	3	**22.5**	0.7	Good
Mourne Beg River	**M27**	3	3	2	4	3.5	2	2	2.5	**22**	0.7	Good
Mourne Beg River	**M28**	3	3	2	4	3.5	2	2	2.5	**22**	0.7	Good
Mourne Beg River	**M29**	3	3	2	4	3.5	2	2	2.5	**22**	0.7	Good

11. Appendix F – biological water quality

Table 11.1 Macro-invertebrate Q-sampling results for aquatic survey sites in the vicinity of Meenbog, October 2021 (continued on next page)

Group	Family	Species	M1	M2	M3	M4	M5	M6	M7	M8	B1	S1	EPA group
Ephemeroptera	Heptageniidae	*Heptagenia sulphurea*		11	4	3	10	53	25	22			A
Ephemeroptera	Heptageniidae	*Ecdyonurus venosus*		4									A
Ephemeroptera	Heptageniidae	*Ecdyonurus dispar*		10		1	3	8	5	13			A
Ephemeroptera	Heptageniidae	*Rhithrogena semicolorata*				1				1			A
Plecoptera	Perlodidae	*Isoperla grammatica*	2	36	14	11	3	4			10		A
Plecoptera	Nemouridae	*Protonemura meyeri*		4	1	2	2	7	8	1	50	49	A
Plecoptera	Chloroperlidae	*Siphonoperla torrentium*				1	4		1		4		A
Ephemeroptera	Leptophlebiidae	*Paraleptophlebia cincta*	1									2	B
Plecoptera	Leuctridae	*Leuctra hippopus*	2				2	1	1	1	5	8	B
Trichoptera	Hydroptilidae	*Oxyethria* sp.	1										B
Trichoptera	Lepidostomatidae	*Lepidostoma hirtum*							2		1		B
Trichoptera	Limnephilidae	Unidentified species				1			1				B
Trichoptera	Sericostomatidae	*Sericostoma personatum*							2				B
Hemiptera	Aphelochiridae	*Aphelocheirus aestivalis*							33	11			B
Ephemeroptera	Baetidae	*Baetis rhodani*	11	1	1	4	11	1	7	22	1		C
Ephemeroptera	Caenidae	*Caenis rivulorum*					1		1				C
Trichoptera	Hydropsychidae	*Hydropsyche siltalai*	15	29	10	11	7	2	4		11		C
Trichoptera	Hydropsychidae	*Hydropsyche instabilis*		2			13	41	9	4			C
Trichoptera	Polycentropodidae	*Polycentropus kingi*	3										C
Trichoptera	Polycentropodidae	*Plectrocnemia conspersa*	2									1	C
Trichoptera	Polycentropodidae	*Polycentropus flavomaculatus*		5	17	12	10	4	2	1	3		C
Trichoptera	Polycentropodidae	*Plectrocnemia geniculata*					2					2	C
Trichoptera	Rhyacophilidae	*Rhyacophila dorsalis*	1	9	1		1				7	3	C
Trichoptera	Rhyacophilidae	*Rhyacophila munda*				1							C
Coleoptera	Dytiscidae	*Ilybius ater*										1	C

Group	Family	Species	M1	M2	M3	M4	M5	M6	M7	M8	B1	S1	EPA group
Coleoptera	Elmidae	*Limnius volckmari*		14	19	23	12	6	7	7			C
Coleoptera	Elmidae	*Elmis aenea*		2			1			4			C
Coleoptera	Elmidae	*Esolus parallelepipedus*					2			1			C
Coleoptera	Gyrinidae	*Gyrinidae* larva		7	3	1	3	4	2	1			C
Diptera	Chironomidae	Unidentified species	2	2	1	4	1	2	1		1		C
Diptera	Pediciidae	*Dicranota* sp.				1	3		1	1			C
Diptera	Simuliidae	Unidentified species	34	7	8	10	13	4	8	9	5	3	C
Diptera	Tipuliidae	*Tipula* sp.	10	2		2	1						C
Gastropoda	Planorbidae	*Ancylus fluviatilis*							2				C
Crustacea	Gammaridae	*Gammarus duebeni*							33	26			C
Arachnida	Hydrachnidiae	Unidentified species				1	1	1		2			C
Annelida	Erpobdellidae	Erpobdellidae species						1					D
Hirudinidae	Glossiphoniidae	*Glossiphonia* sp.								4			D
Crustacea	Asellidae	*Asellus aquaticus*							1	4			D
Mollusca	Lymnaeidae	*Ampullacaeana (Radix) balthica*						2		4			D
Annelida	Naididae (Tubificidae)	Naididae (Tubificidae) larva			3	5	3		2	2			E
Annelida	Oligochaeta	Unidentified species	4	4	2	4						1	n/a
Total Abundance			**88**	**149**	**84**	**99**	**109**	**141**	**158**	**141**	**98**	**70**	
Ephemeroptera Plecoptera Trichoptera (EPT) taxonomic diversity *n*			**9**	**10**	**7**	**11**	**13**	**9**	**13**	**8**	**9**	**6**	
% EPT			**43.2**	**74.5**	**57.1**	**48.5**	**63.3**	**87.1**	**43**	**47.4**	**93.9**	**92.9**	
Q-rating			Q3-4	Q4	Q4	Q4-5	Q4-5	Q4	Q4	Q4	Q4	Q3-4	
WFD status			Mod	Good	Good	High	High	Good	Good	Good	Good	Mod	

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