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Freshwater pearl mussel survey of Northern 2011.

Reid, N., Preston, J., & Keys, A. (2011). *Freshwater pearl mussel survey of Northern 2011.* (Research and Development Series). Northern Ireland Environment Agency.

Document Version:
Publisher's PDF, also known as Version of record

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Freshwater pearl mussel survey of Northern Ireland 2011

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Research and Development Series 10/XX
A report commissioned by the Northern Ireland Environment Agency

Freshwater pearl mussel survey of Northern Ireland 2011

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NHRP contract number: CON X/X (XXX)
Quercus Project: QU11-01

Quercus hosts the Natural Heritage Research Partnership between the Northern Ireland Environment Agency and Queen's University Belfast.
www.quercus.ac.uk

This report should be cited as follows:

Reid, N., Preston, S.P. & Keys, A. (2011) *Freshwater pearl mussel survey of Northern 2011*. Report prepared by the Natural Heritage Research Partnership, *Quercus*, Queen's University Belfast for the Northern Ireland Environment Agency. Northern Ireland Environment Agency Research and Development Series No. 10/XX.

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The opinions expressed in this report do not necessarily reflect the current opinion or policy of the Northern Ireland Environment Agency.

EXECUTIVE SUMMARY

1. The freshwater pearl mussel *Margaritifera margaritifera* is Ireland's only globally 'Endangered' species and the EU Habitats Directive requires the designation of Special Conservation Areas (SACs) or Areas of Special Scientific Interest (ASSIs) for its protection. The species has undergone dramatic declines throughout its range including in Northern Ireland.

2. Freshwater pearl mussels are extant in six rivers in Northern Ireland. The Ballinderry, Owenkillew and Swanlinbar are currently designated as SACs, the Tempo is currently designated as an ASSI whilst the Owenreagh and Waterfoot are proposed ASSIs.

3. Initial condition assessments for the three SAC rivers were carried out by Killeen (2007) and populations were found to be in "Unfavourable declining" condition.

4. The current survey reassessed the condition assessment of the three SAC rivers and conducted the first baseline assessments of the three ASSI and proposed ASSI rivers.

5. A total of 12,947 freshwater pearl mussels were recorded on SAC designated rivers (Ballinderry, Owenkillew and Swanlinbar). Whilst there was a +4.1% increase in the numbers of mussels recorded, there was no significant temporal trend in abundance and populations judged to be stable since the previous survey. Nevertheless, water quality and other factors resulted in an overall condition assessment for 2011 judged to be "Unfavourable no change".

6. A total of 9,032 freshwater pearl mussels were recorded on the ASSI and proposed ASSI rivers (Tempo, Owenreagh and Waterfoot). The current survey discovered a substantial population (8,195 mussels) on the Owenreagh which represents the population data for this river. Numbers declined by -17.9% on the Tempo river. The Waterfoot had also been surveyed previously; however, there were difficulties in direct comparisons of individual river sections between the current survey and previous surveys. Water quality and other factors resulted in an overall condition assessment for 2011 judged to be "Unfavourable" for the Owenreagh and "Unfavourable declining" the Tempo and Waterfoot.

7. Overall, a total of 21,979 freshwater pearl mussels were recorded on six rivers throughout Northern Ireland.

CONTENTS

INTRODUCTION

The freshwater pearl mussel *Margaritifera margaritifera* is Ireland's only globally 'Endangered' species (IUCN 1996). It is protected under Appendix II of the Bern Convention and listed under Annex II and V of the EU Habitats Directive (92/43/EEC) i.e. a species whose conservation requires the designation of sites at which it occurs, such as Special Conservation Areas (SACs) or Areas of Special Scientific Interest (ASSIs). Exploitation such as taking specimens from the wild prohibited except under licence.

The species has undergone dramatic declines throughout its range (Hastie & Cosgrove, 2001), including throughout the British Isles (Cosgrove *et al*., 2000). The stronghold for the species in Great Britain is Scotland where there are 21 sites designated with the freshwater pearl mussel as the named feature (Anon 2011).

The species was once common on many rivers in Northern Ireland (Kerney 1999). However, recent surveys have identified small beds of *M. margaritifera* in only a few river systems where they form small, senescent populations (Killeen, 2007). Declines have been such that it has been estimated that the species may be totally extinct in Northern Ireland by 2098 (Wilson 2011a). Consequently, the freshwater pearl mussel is the named feature in three rivers designated as SACs: namely the Ballinderry, Owenkillew and Swanlinbar and one river as an ASSI: namely the Tempo (Fig. 1) whilst two rivers as currently proposed as future ASSIs: namely the Owenreagh and Waterfoot. Designated sites are subject to regularly monitoring whilst baseline data are required for proposed sites.

Initial condition assessments for the SAC rivers were carried out by Killeen (2007). Total counts were conducted and the status of all sites was found to be "unfavourable declining".

The aim of the current survey was to reassess the present condition of freshwater pearl mussel populations on the 3 SAC rivers and conduct the first baseline conservation assessments for the 3 ASSI or proposed ASSI rivers (for which some previous data are available).

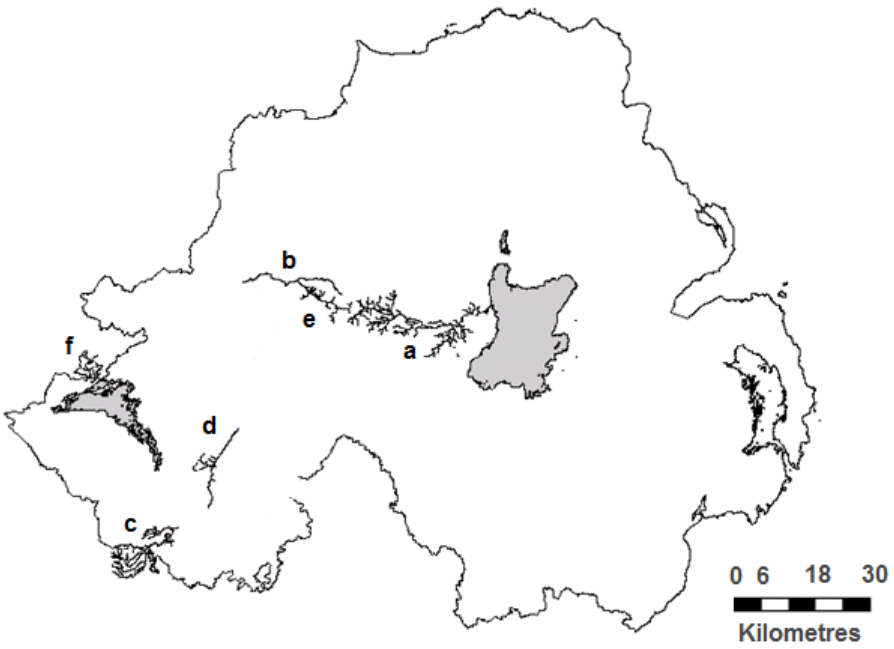

Fig. 1 Those rivers with extant freshwater pearl mussel populations currently designated as SACs are the **a)** Ballinderry, **b)** Owenkillew and **c)** Swanlinbar whilst the **d)** Tempo is currently an ASSI and the **e)** Owenreagh and **f)** Waterfoot are proposed ASSIs.

METHODS

Total counts

Mussels occur in discrete beds (sub-populations) within defined stretches or sections of each river. Killeen (2007) identified and surveyed mussel beds on the three SAC designated rivers whilst Preston *et al.* (2006) previously surveyed remnant populations on the Tempo ASSI and Waterfoot proposed ASSI. There has been no previous survey of the Owenreagh proposed ASSI.

We returned to the same mussel beds surveyed by Preston *et al.* (2006) and Killeen (2007) and repeated an identical survey during early 2011. No previous data existed for the Owenreagh. However, Wilson (2011) conducted a low resolution survey of the occurrence of mussels on the Owenreagh at sites separated by 500m along the length of their range during 2009 (unpublished data). These data were used to

identify the stretches of Owenreagh on which mussel beds were known to occur and thereafter identical methods to those used on the other rivers.

Each mussel bed was surveyed using a standard bathoscope (perspex-bottomed viewing bucket) in water shallow enough for wading (maximum of 1.2m). Absolute counts of mussels were conducted within each sub-population and their locations recorded using a handheld GPS. Maps of discrete river sections were created to show the location of each survey section at a scale of 1:10,000 using ArcGIS 10 (ESRI, California, USA).

Any dead shells found on the river banks were collected. The size structure of each populations was estimated by measuring the total length (mm) of all dead shells and plotting their frequency distribution. The substrate type and presence of filamentous algae within each section of river was also recorded. For substrate, the river bottom was disturbed by kicking to a depth of 10cm and observing whether a silt 'plume' was produced (Killeen 2007).

For SAC rivers only, the total numbers of mussels enumerated during the current survey were compared directly with those from Killeen (2007) to ascertain if there was any significant temporal trend using a Wilcoxon signed rank test for matched paired (a non-parametric test for small sample sizes).

Water chemistry

Water chemistry data were obtained from NIEA Water Management Unit for all six sites. Datasets covered the period January 2007 to March 2011. As in the previous assessment carried out by Killeen (2007) datasets were obtained for orthophosphate, nitrate, suspended solids and BOD levels only. These parameters are thought to be detrimental to the recruitment of mussels (Bauer, 1988). However, it is now believed that the target levels set by Bauer (1998) may be too high for effective recruitment in Ireland (Moorkens, 2006). Mean values were calculated and variance in the time-series for each of the four parameters was plotted. Indicative threshold target values were taken from Moorkens (2006) as in Table 1.

Table 1 Threshold values for four water chemistry parameters necessary for freshwater pearl mussel recruitment.

Parameter	Bauer (1988) mg/l	Moorkens (2006) mg/l
Orthophosphate	0.03	0.005
Nitrate	0.50	0.125
Suspended Solids	<10.00	<10.000
BOD	<1.40	<1.400

Conservation Assessments

We assessed the current conservation status of each river using the JNCC Common Standards Monitoring categories (Table 2) defining each by the same criteria used by Young *et al.* (2003) and Killeen (2007) presenting the results in a Favourable Condition Table or FCT (Table 3).

Table 2 Conservation Assessment for freshwater pearl mussel following the JNCC Common Standards Monitoring categories.

Favourable	Unfavourable
Maintained	Declining
Recovered	No change
	Recovering
	Partially destroyed (habitats)
	Totally destroyed (habitats)/lost from site

Table 3 Favourable Condition Table (FCT) criteria used to assess the conservation status of the freshwater pearl mussel (extracted from Killeen 2007).

Attribute	Target	Notes
Mussels		
Density	Potentially suitable habitat at capacity (least 10 mussels/m^2).	Target in UK protocol (Young *et al*. 2003) is 10 mussels/m^2 in favourable habitat.
Numbers of live individuals	No recent decline	Based on comparative results from the most recent surveys.
Numbers of dead	<1% of population	1% considered to be indicative of natural losses. Age of dead shells can be used to provide information if loss level is otherwise in doubt – if all dead shells are fresh this would indicate a more serious problem than scattered disintegrating shells of various ages.
Age structure	At least 20% of population ≤65mm	Target in UK protocol (Young *et al*. 2003).
Age structure 2	At least some mussels ≤30mm	Target in UK protocol (Young *et al*. 2003).
Water Quality		
Orthophosphate	0.005mg/l (<0.030)	The target level given in the FCT based upon Bauer (1988) is <0.030mg/l, but recent evidence from Ireland (Moorkens, 2006) found that the highest median levels associated with effectively recruiting populations are 0.005mg/l.
Nitrate	0.125mg/l (<0.500)	No target given in FCT. Bauer (1988) gives <0.500mg/l, but Moorkens (2006) found that the highest median levels associated with effectively recruiting populations are 0.125mg/l.
Suspended Solids	<10mg/l	Suspended solids should be rare rather than chronic and attributable to natural conditions.
BOD	<1.40mg/l	No target given in FCT but Bauer (1988) gives <1.40mg/l.
Substrate Condition		
Siltation	No plumes of silt when substrate kicked to 10cm deep	A 'plume' is an obvious flush of silt, produced when stones are lifted from the substrate or submerged vegetation is disturbed, such that visibility of the river bed is momentarily obscured.
Redox measurements	<20% loss in redox value at 5cm depth	Based on work by Geist *et al*. (in prep). Results from a recent survey of the River Ehen in Cumbria (Killeen 2006) show that young mussels and juveniles were present only in the most highly oxygenated riffle areas where the loss in redox value was less than 20% at 5cm depth.
Filamentous algae	None (<5% cover)	Target in UK protocol Young *et al*. 2003). Any filamentous algae should be wispy and ephemeral.
Adjacent Land Use Issues	No damaging activities	Damaging activities are those considered to contribute more suspended solids and/or nutrients than would be expected in functioning mussel habitats.
Evidence of pearl fishing	None	Based upon evidence (i.e. opened shells caches on banks) or information from locals.

RESULTS

Populations in SAC rivers

A total of 12,947 freshwater pearl mussels were recorded on SAC designated rivers (Ballinderry, Owenkillew and Swanlinbar). All sections of each river had been surveyed previously during either 2004 (NIEA 2004) or 2007 (Killeen 2007) with the exception of Point transect A5 on the Owenkillew. Thus, excluding this section the total number of mussels observed on SAC rivers during 2011 was 12,727 compared to 12,229 during the previous survey. Whilst this represented a +4.1% increase in the numbers of mussels observed, there was no significant difference between the surveys (Wilcoxon signed rank test for matched pairs = 0.019, p=0.984).

Populations in ASSI or proposed ASSI rivers

A total of 9,032 freshwater pearl mussels were recorded on the Tempo ASSI and Owenreagh and Waterfoot proposed ASSIs. Most notably, 8,195 mussels of these mussels were recorded on the Owenreagh proposed ASSI representing the first baseline survey of this river. The number of live mussels observed on the Tempo ASSI declined by -17.9% from 525 during 2009 (Wilson 2011) to 431 during 2011. The Waterfoot proposed ASSI had also been surveyed previously, however, there were difficulties in direct comparisons of individual river sections between the current survey (where the area surveyed was known) and previous surveys (Preston *et al*. 2007; Wilson 2011) were the area surveyed was not well reported.

Conservation status

A total of 21,979 freshwater pearl mussels were recorded on six rivers throughout Northern Ireland. There was no evidence for any temporal trend in abundance on SAC designated rivers suggesting populations have remained stable since 2004/09. Water quality criteria failed in the majority of cases and the current condition assessment of all SACs was judged as “Unfavourable no change”. The status of the Tempo ASSI and Waterfoot proposed ASSI was determined as “Unfavourable declining” due to poor water quality and an apparent reduction in mussel numbers

whilst the Owenreagh proposed ASSI was determined as "Unfavourable" as no assessment of temporal change could be made.

Ballinderry SAC

A total of 3 sections were surveyed on the Ballinderry SAC (Fig. 2). A total of 846 live mussels were observed (Table 4). This represents a -14.5% decrease on the 989 mussels observed in the previous survey during 2007 (Killeen 2007). For detailed maps of each section and summary tables see Appendix 1.

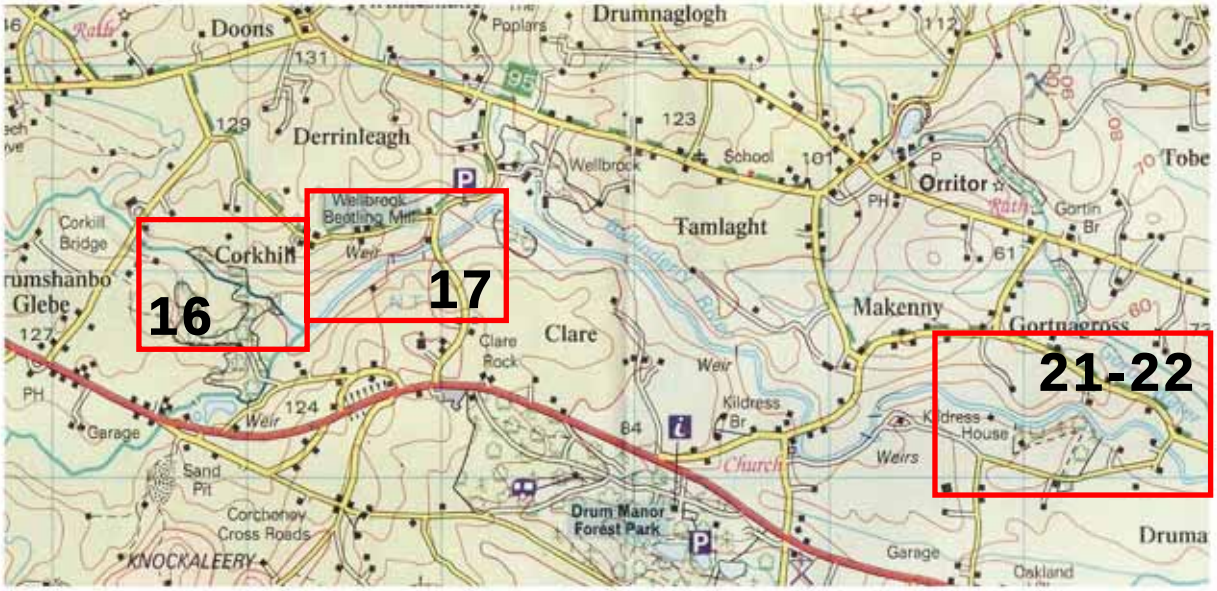

Fig. 2 Survey sections on the Ballinderry SAC numbered to be consistent with Killeen (2009).

Table 4 Total numbers of live mussels recorded in each section of the Ballinderry SAC during the previous and current studies.

Section	Location	No. of mussels	
		2007	2011
16	Downstream of Corkhill Bridge	643	550
17	Downstream of Wellbrook Beetling Mill	113	106
20	To Kildress House		
21	To u/s Auglish Bridge	233	190
22	To Auglish Bridge		
	Total	**989**	**846**

A total of 67 dead shells were collected. No mussels <65mm were recorded and the frequency distribution of shell size suggested that the population was composed predominately of aged adults (Fig. 3). Several moribund and living mussels were found on the margins of the river (<30mm water depth) in Section 16 (downstream of Corkhill Bridge) and it was suspected that these mussels had been washed out during a preceding period of heavy flow during January 2011. These individuals were moved into deeper water.

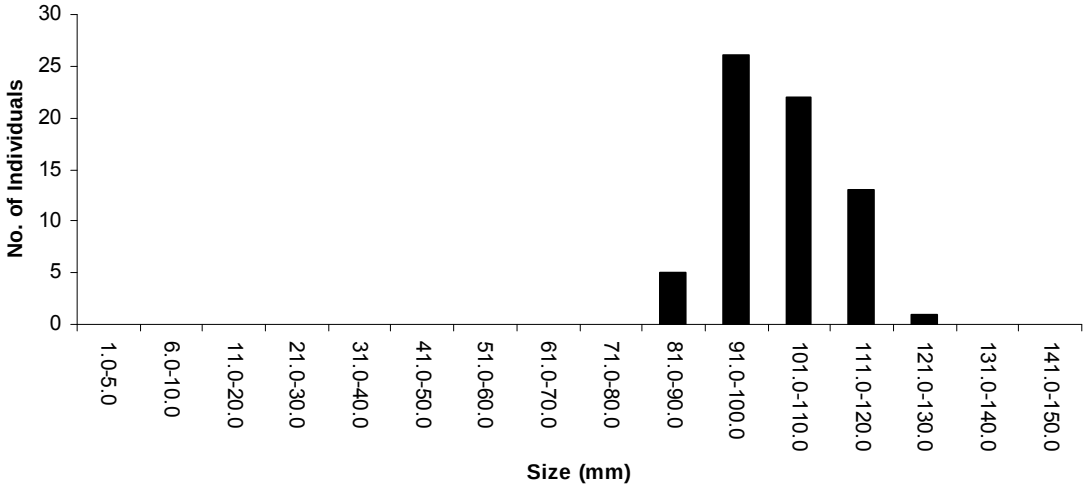

Fig 3 Frequency distribution of shell size (derived from dead shells collected) found on the Ballinderry SAC.

Water chemistry was assessed at two sampling stations at i) Corkhill Bridge (H734793) and ii) King's Bridge (H812765) covering the length of river inhabited by mussels for the period of January 2007 to March 2011 (Fig. 4). Orthophosphate levels ranged from 0.01 to 0.13mg/l (mean = 0.04). Nitrate levels ranged from 0.47 to 2.91mg/l (mean = 1.58). Levels of suspended solids were generally below 10mg/l but rose above this level on a number of occasions, most notably up to a maximum of 169mg/l and 110mg/l at both sites respectively during July 2008. BOD ranged from 1-5.8mg/l (mean = 1.79).

A conservation assessment using criteria from Table 3 suggested that the population on the Ballinderry SAC is currently "Unfavourable no change" (Table 5).

i) Corkhill Bridge **ii) King's Bridge**

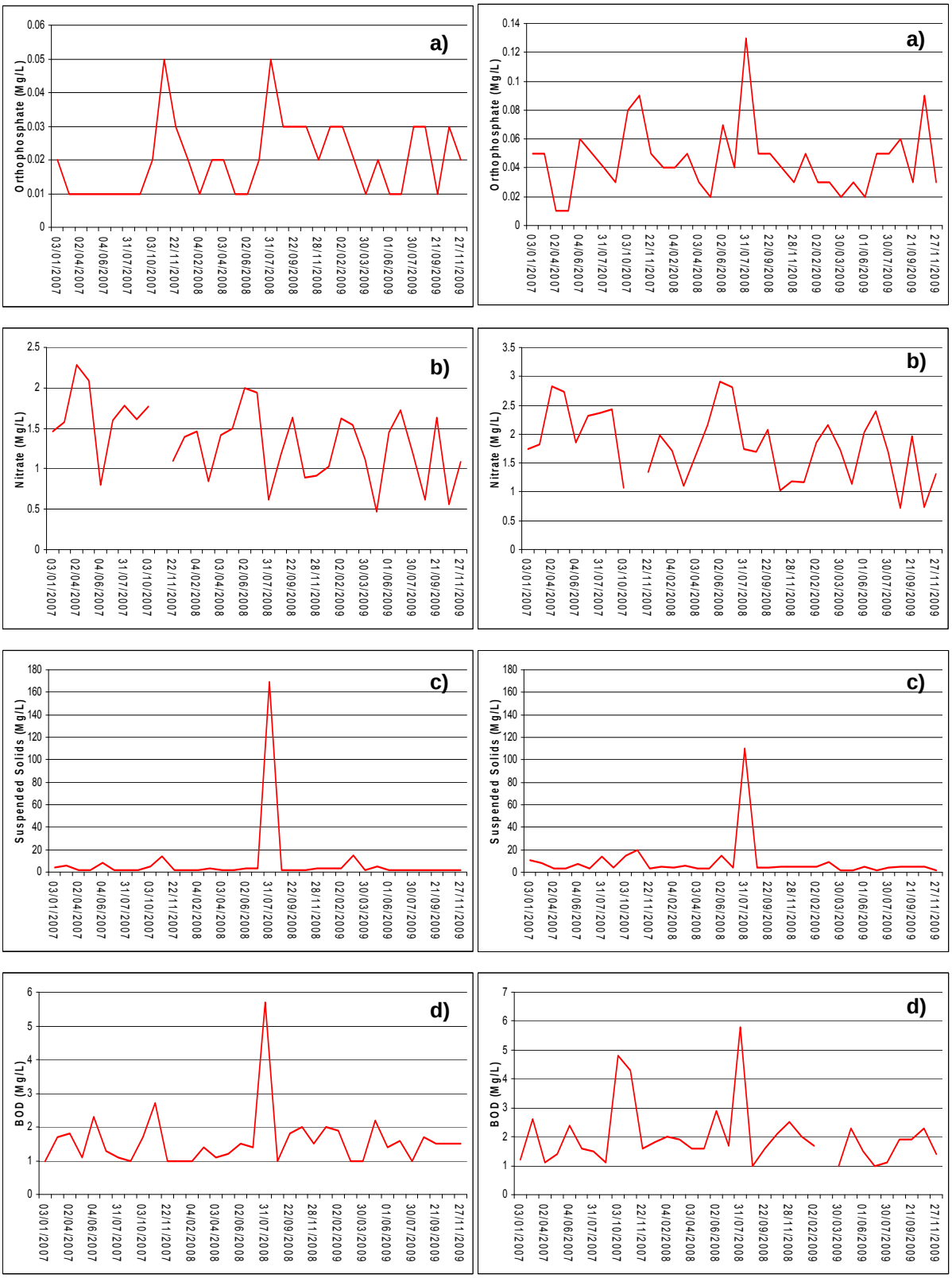

Fig 4 Variance in **(a)** orthophosphate, **(b)** nitrate, **(c)** suspended solids and **(d)** biological oxygen demand from January 2007 to March 2010 at **i)** Corkhill Bridge and **ii)** King's Bridge (data obtain from the NIEA Water Management Unit).

Table 5 Conservation Assessment for the Ballinderry SAC freshwater pearl mussel population.

Attribute	Target	Actual	Pass/Fail
Mussels			
Density	Potentially suitable habitat at capacity (or at least 10 mussels/m^2)	Patchy distribution. Many areas of suitable substrate with no mussels.	Fail
Number of live individuals	No decline since most recent survey	-14.5% decrease in numbers since previous assessment (2007)	Fail
Numbers of dead shells	<1% of population	67 dead : 846 alive (8% dead)	Fail
Age structure 1	At least 20% of population ≤65mm	None	Fail
Age structure 2	At least some mussels ≤ 30mm	None	Fail
Water Quality (2007-2010)			
Orthophosphate	0.005mg/l (<0.03)	0.04mg/l (range: 0.01-0.13)	Fail
Nitrate	0.125mg/l (<0.5)	1.58mg/l (range 0.47-2.91)	Fail
Suspended Solids	<10mg/l	Generally <10mg/l (max= 169)	Pass
BOD	<1.4mg/l	1.79mg/l (range 1-5.8)	Fail
Substrate Condition			
Siltation	No plumes of silt when substrate kicked to 10cm depth	100% of samples plumed	Fail
Redox measurements	Measurements <20% loss in redox value at 5cm depth	Not assessed	Unknown
Macrophytes		*Ranunculus* in places	Not assessed
Filamentous algae	None (<5% cover)	Generally <10% but greater cover further downstream	Fail
Adjacent Land Use Issues		Cattle poaching, bank erosion, severe scarring of the river bed and banks by winter floods	Fail
Evidence of pearl fishing	None	No exploitation evident	Pass
			OVERALL CONDITION: No change

Owenkillew SAC

One section was surveyed on the Owenkillew SAC (Fig. 5) in addition to 21 point transects and 4 line transects previously surveyed by Killeen (2007) and NIEA (2004) respectively. A total of 8,474 live mussels were observed (Table 6). This represents a +6.4% increase on the 7,931 mussels observed during previous surveys. For detailed maps of each section and summary tables see Appendix 1.

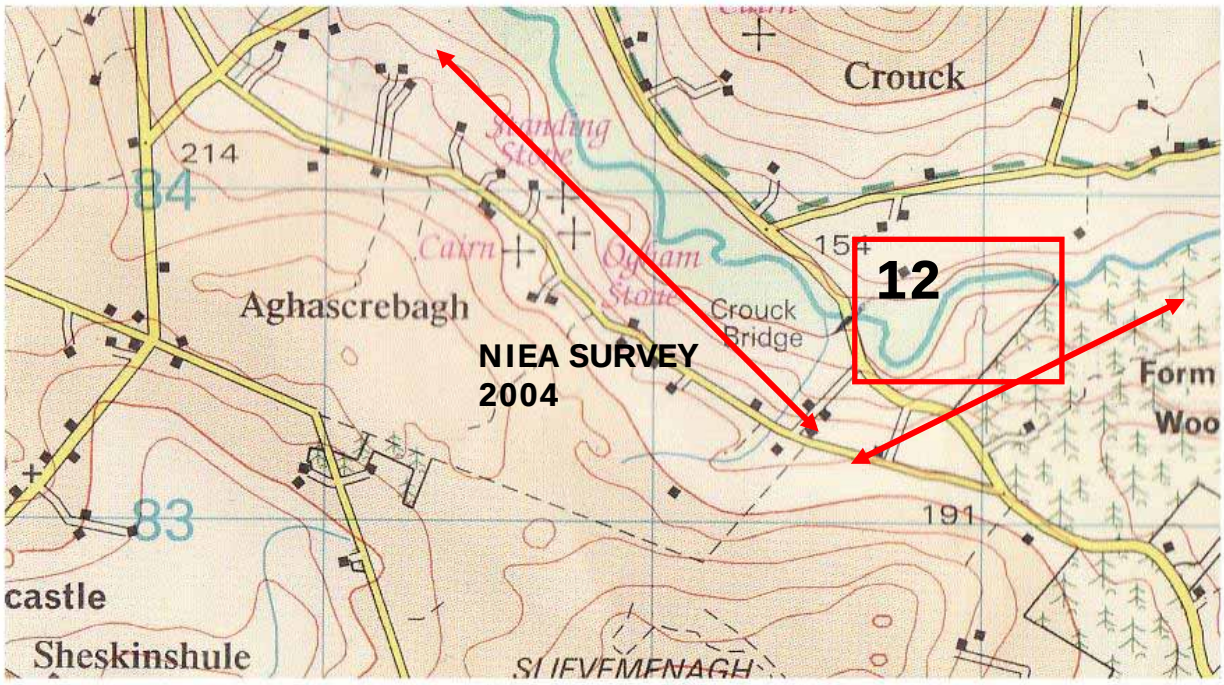

Fig. 5 Survey sections on the Owenkillew SAC numbered to be consistent with Killeen (2009) with red arrows indicating the extent of points and transects previously surveyed by NIEA (2004).

Table 6 Total numbers of live mussels recorded in each section of the Owenkillew SAC during the previous and current studies.

ID	Description	No. of mussels		
		2004	2007	2011
12	Upstream of Crouck Bridge		824	2,391
Points	21 points transects	6,380		5,467
Transects	4 x 50m line transects	727		616
	Total	**7,931**		**8,474**

A total of 147 dead shells were collected. No mussels <65mm were recorded and the frequency distribution of shell size suggested that the population was composed predominately of aged adults (Fig. 6). Nevertheless, several juvenile mussels including one estimated to be <5 years old were identified by NIEA staff during an 'emergency response' in late March 2011 (Tony Waterman pers. comms.). This may suggest that some recruitment has occurred during the past 5-10 years.

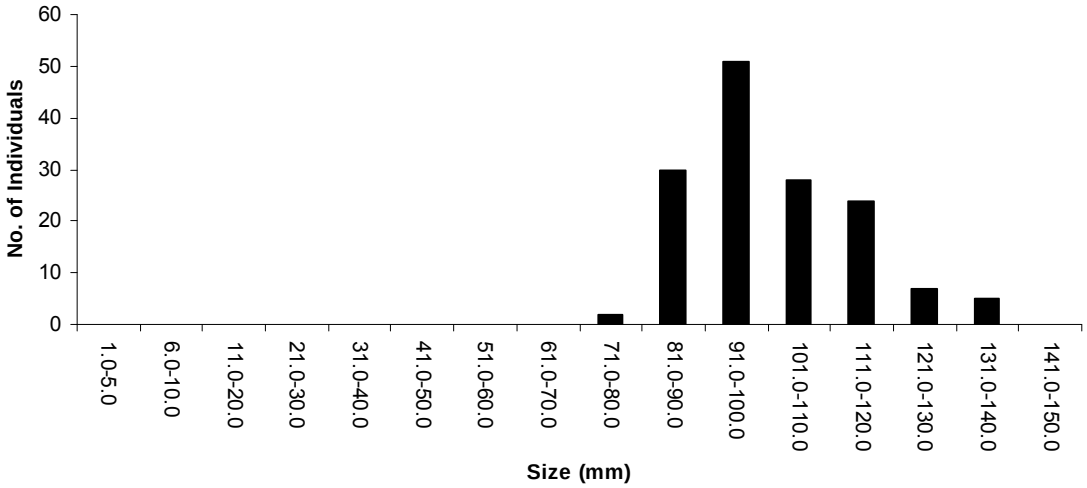

Fig 6 Frequency distribution of shell size (derived from dead shells collected) found on the Owenkillew SAC.

Water chemistry was assessed at Monanameal Bridge (H614848) which was dowstream of the pearl mussel population for the period of January 2007 - March 2011 (Fig. 7). Orthophosphate levels ranged from 0.003 to 0.02mg/l (mean = 0.009). Nitrate levels ranged from 0.003 to 0.806mg/l (mean = 0.22). Levels of suspended solids were generally below 10mg/l but rose above this level on a number of occasions, most notably up to a maximum of 34mg/l during July 2008. BOD ranged from 1-3.6mg/l (mean = 1.61).

A conservation assessment using criteria from Table 3 suggests that the population on the Owenkillew SAC is currently "Unfavourable no change" (Table 7).

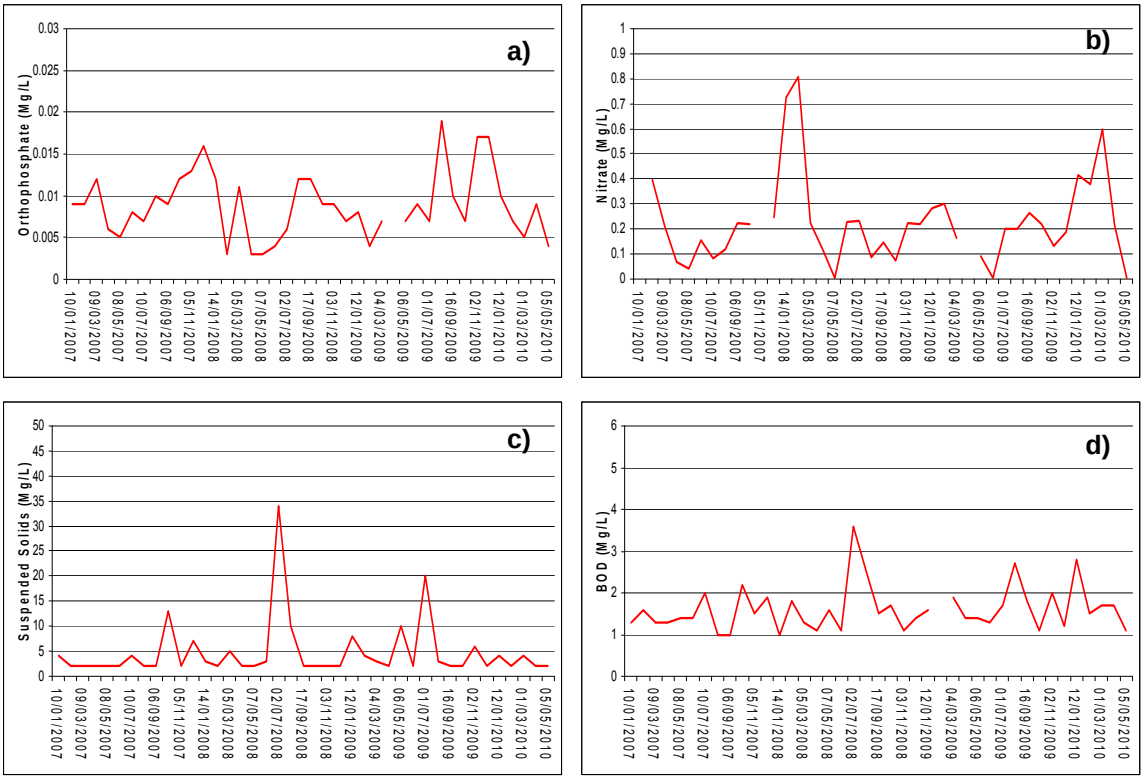

Fig 7 (a) Variance in **(a)** orthophosphate, **(b)** nitrate, **(c)** suspended solids and **(d)** biological oxygen demand from January 2007 to March 2010 (data obtain from the NIEA Water Management Unit).

Table 7 Conservation Assessment for the Owenkillew SAC freshwater pearl mussel population.

Attribute	Target	Actual	Pass/Fail
Mussels			
Density	Potentially suitable habitat at capacity (or at least 10 mussels/m^2)	Some dense beds but large areas of suitable substrate devoid of mussels	Fail
Number of live individuals	No decline since most recent survey	+6.4% increase in numbers since previous survey (NIEA 2004; Killeen 2007)	Pass
Numbers of dead shells	<1% of population	147 dead : 5467 alive (2.7%)	Fail
Age structure 1	At least 20% of population ≤65mm	Several individuals thought to be <5-10 years old found by NIEA (2011)	Fail
Age structure 2	At least some mussels ≤ 30mm	None	Fail
Water Quality (2007-2010)			
Orthophosphate	0.005mg/l (<0.030)	0.009mg/l (range 0.003-0.020)	Fail
Nitrate	0.125mg/l (<0.500)	0.22mg/l (0.003-0.806)	Fail
Suspended Solids	<10mg/l	Generally <10mg/l (max = 34)	Pass
BOD	<1.40mg/l	1.61mg/l (1.00-3.60)	Fail
Substrate Condition			
Siltation	No plumes of silt when substrate kicked to 10cm depth	Some plumes of silt present especially in slow water	Fail
Redox measurements	Measurements <20% loss in redox value at 5cm depth	Not assessed	Unknown
Macrophytes		*Ranunculus* in places	Not assessed
Filamentous algae	None (<5% cover)	Present but <5%	Pass
Adjacent Land Use Issues		Cattle poaching, severe bank erosion due to winter floods & coniferous forestry	Fail
Evidence of pearl fishing	None	No exploitation evident	Pass
			OVERALL CONDITION: No change

Swanlinbar SAC

A total of 4 sections were surveyed on the Swanlinbar SAC (Fig. 8). A total of 3,627 live mussels were observed (Table 8). This represents a +8.8% increase on the 3,309 mussels observed in the previous survey during 2007 (Killeen 2007). For detailed maps of each section and summary tables see Appendix 1.

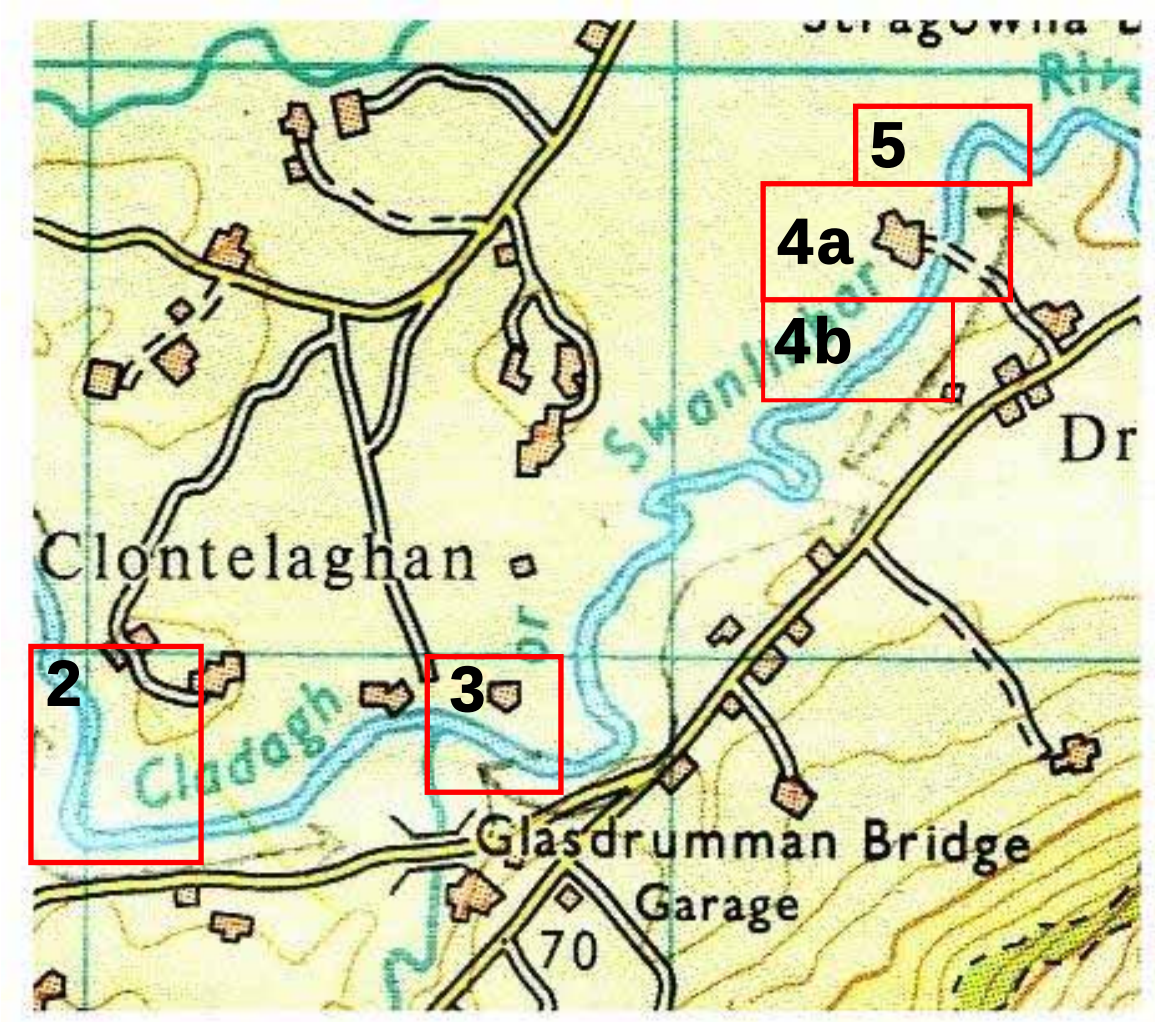

Fig. 8 Survey sections on the Swanlinbar numbered to be consistent with Killeen (2009).

Table 8 Total numbers of live mussels recorded in each section of the Swanlinbar SAC during the previous and current studies.

Section	Location	No. of mussels	
		2007	2011
2	Upstream of Glasdrumman Bridge	1,112	1,396
3	Downstream of Glasdrumman Bridge	53	84
4a	Around the Ulster Way bridge at Drumroosk	1,065	1,128
4b	Upstream of the Ulster Way bridge at Drumroosk	684	644
5	Downstream of Stragowna Bridge	395	375
	Total	**3,309**	**3,627**

A total of 111 dead shells were collected. No mussels <65mm were recorded and the frequency distribution of shell size suggested that the population was composed predominately of aged adults (Fig. 9a). Nevertheless, a juvenile mussel (50mm in length) was found in loose gravel substrate and was estimated at approximately 10 years old (Fig. 9b).

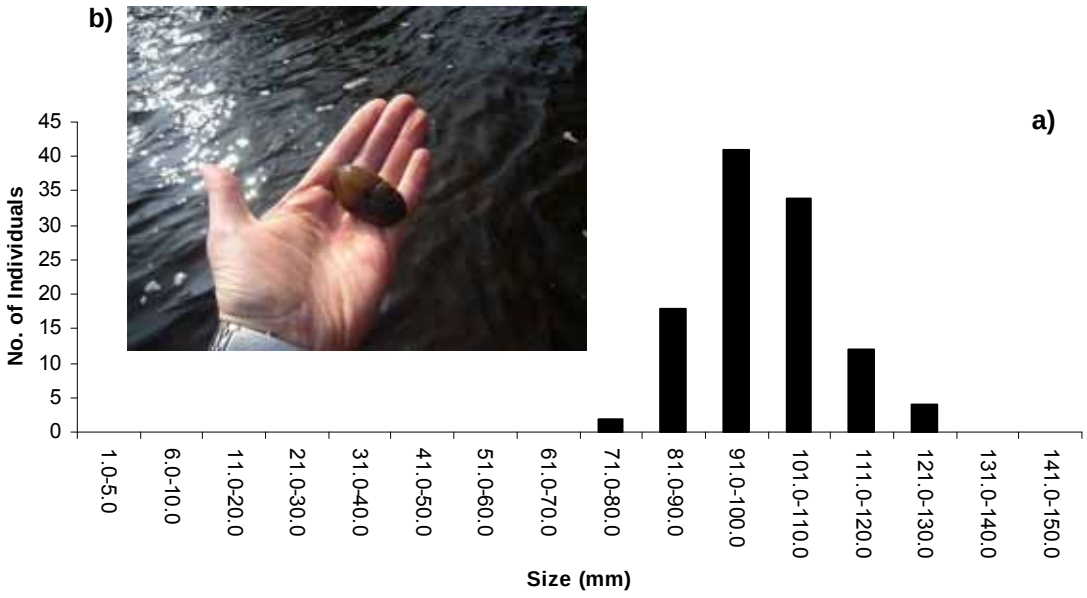

Fig 9 (a) Frequency distribution of shell size (derived from dead shells collected) and **(b)** a juvenile mussel estimated to be approx. 10 years old found on the Swanlinbar SAC.

Water chemistry was assessed at Thompson's Bridge (H253313) which was c. 3km dowstream of the pearl mussel population for the period of January 2007 - March 2011 (Fig. 10). Orthophosphate levels ranged from 0.01 to 0.03mg/l (mean = 0.01) and were lower than those recorded during the previous monitoring period of 1999 to 2006 (Killeen 2007). Nitrate levels ranged from 0.06 to 0.60mg/l (mean = 0.29) and were similar to those recorded during the previous monitoring period (Killeen 2007). Levels of suspended solids were generally below 10mg/l but rose above this level on four occasions up to a maximum of 26mg/l during late 2009. BOD ranged from 1-2mg/l (mean = 1.43) and was lower than levels recorded previously (Killeen, 2007).

A conservation assessment using criteria from Table 3 suggests that the population on the Swanlinbar SAC is currently "Unfavourable no change" (Table 9).

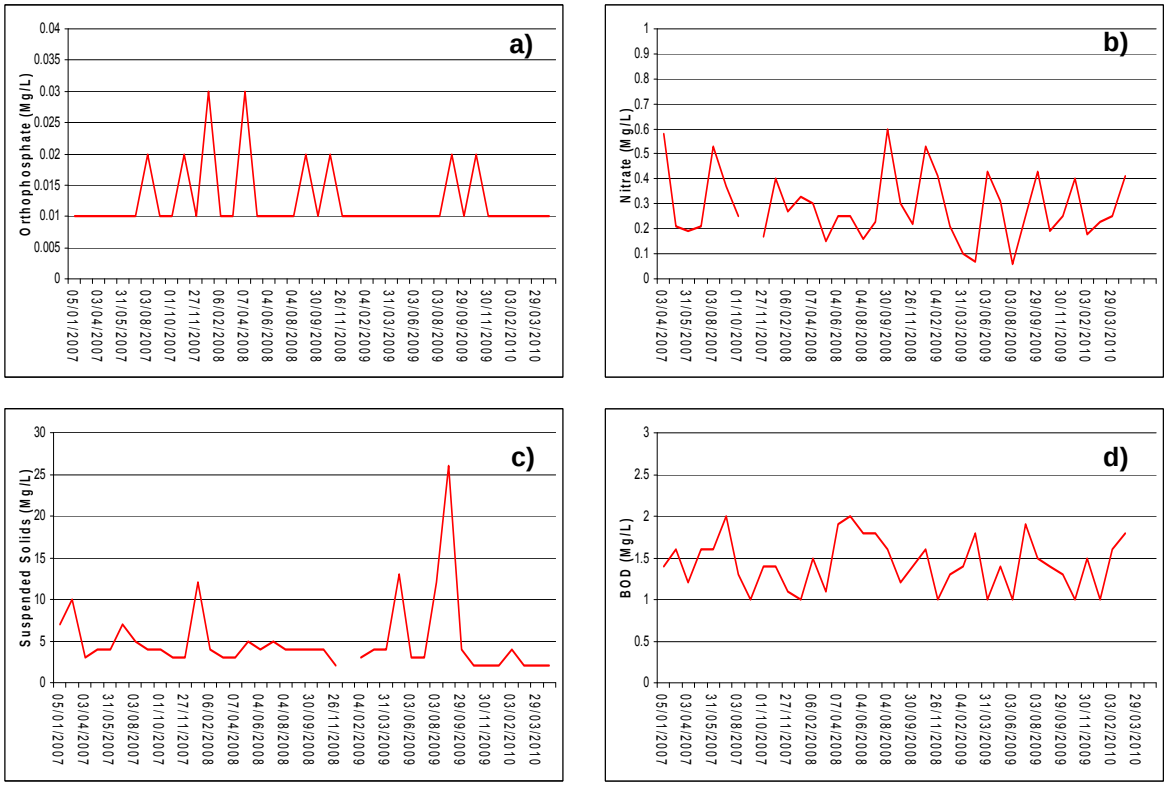

Fig 10 (a) Variance in **(a)** orthophosphate, **(b)** nitrate, **(c)** suspended solids and **(d)** biological oxygen demand from January 2007 to March 2010 (data obtain from the NIEA Water Management Unit).

Table 9 Conservation Assessment for the Swanlinbar SAC freshwater pearl mussel population.

Attribute	Target	Actual	Pass/Fail
Mussels			
Density	Potentially suitable habitat at capacity (or at least 10 mussel/m^2)	Mussels widespread but density very low except in the most suitable riffles	Fail
Number of live individuals	No decline since most recent survey	+8.8% increase in numbers since previous assessment (2007)	Pass
Numbers of dead shells	<1% of population	111 dead : 3,627 live (3.4% dead)	Fail
Age structure 1	At least 20% of population ≤65mm	Only one live individual at 50mm	Fail
Age structure 2	At least some mussels ≤30mm	None	Fail
Water Quality (2007-2010)			
Orthophosphate	0.005mg/l (<0.03)	0.01mg/l (range: 0.01-0.03)	Fail
Nitrate	0.125mg/l (<0.5)	0.29mg/l (range: 0.06-0.60)	Fail
Suspended solids	<10mg/l	Generally <10mg/l (max = 26)	Pass
BOD	<1.4mg/l	1.43mg/l (range: 1-2)	Fail
Substrate Condition			
Siltation	No plumes of silt when substrate kicked to 10cm depth	40% of samples plumed	Fail
Redox measurements	Measurements <20% loss in redox value at 5cm depth	Not assessed	Unknown
Macrophytes		*Ranunculus* in places, plus occasional *Myriophyllum*	Not assessed
Filamentous algae	None (<5% cover)	Present in all section but generally <10%	Fail
Adjacent Land Use Issues		Cattle poaching, bank erosion and coniferous forestry (in ROI)	Fail
Evidence of pearl fishing	None	No exploitation evident	Pass
			OVERALL CONDITION No change

Tempo ASSI

A total of 3 sections were surveyed on the Tempo non-SAC (Fig. 11). A total of 431 live mussels were observed (Table 10). This represents a -17.9% decrease on the 525 mussels observed in the last previous survey during 2009 (Wilson 2011). A total of 26 dead shells observed. For detailed maps of each section and summary tables see Appendix 1.

Fig. 11 Survey sections on the Tempo surveyed for comparison with Wilson (2011).

Table 10 Total numbers of live mussels recorded in each section of the Tempo non-SAC in previous and the current survey.

Sections	Location	Central Grid Reference	No. of mussels		
			2006*	2009†	2011
1 / D* / E†	Upstream of A4 road bridge	H 3420 3925	100	181	125
2 / G* / I†	At Old Coach Road ford	H 3395 3975	200	169	162
3 / P* / R†	Upstream of Drumglone Bridge	H 3355 4275	170	175	144
		Total	**470**	**525**	**431**

A total of 26 dead shells were collected and added to a larger sample of 105 dead shells previously collected by NIEA (provided courtesy of Tony Waterman) to assess age structure. The frequency distribution of shell size (n = 131) suggested that the population was composed predominately of aged adults (Fig. 15).

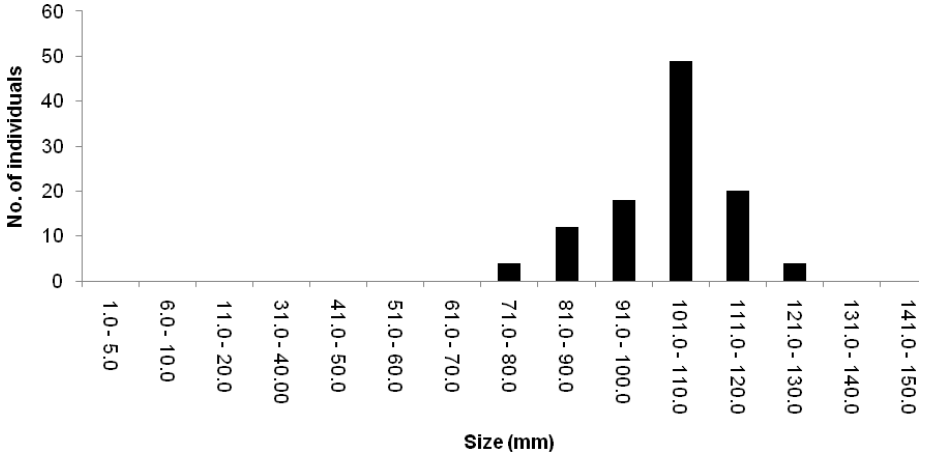

Fig 15 Frequency distribution of shell size (derived from dead shells collected) at the Tempo ASSI.

Water chemistry was assessed at the A4 Road Bridge (H342392) for the period of January 2007 - March 2011 (Fig. 12). Orthophosphate levels ranged from 0.01 to 0.08mg/l (mean = 0.01). Nitrate levels ranged from 0.47 to 1.88mg/l (mean = 1.13). Levels of suspended solids were generally below 10mg/l but rose above this level on four occasions up to a maximum of 46mg/l during Nov 2007. BOD ranged from 1.00-3.80mg/l (mean = 1.67).

A Conservation Assessment using criteria from Table 3 suggested that the population on the Tempo ASSI is currently in “Unfavourable declining” condition (Table 11).

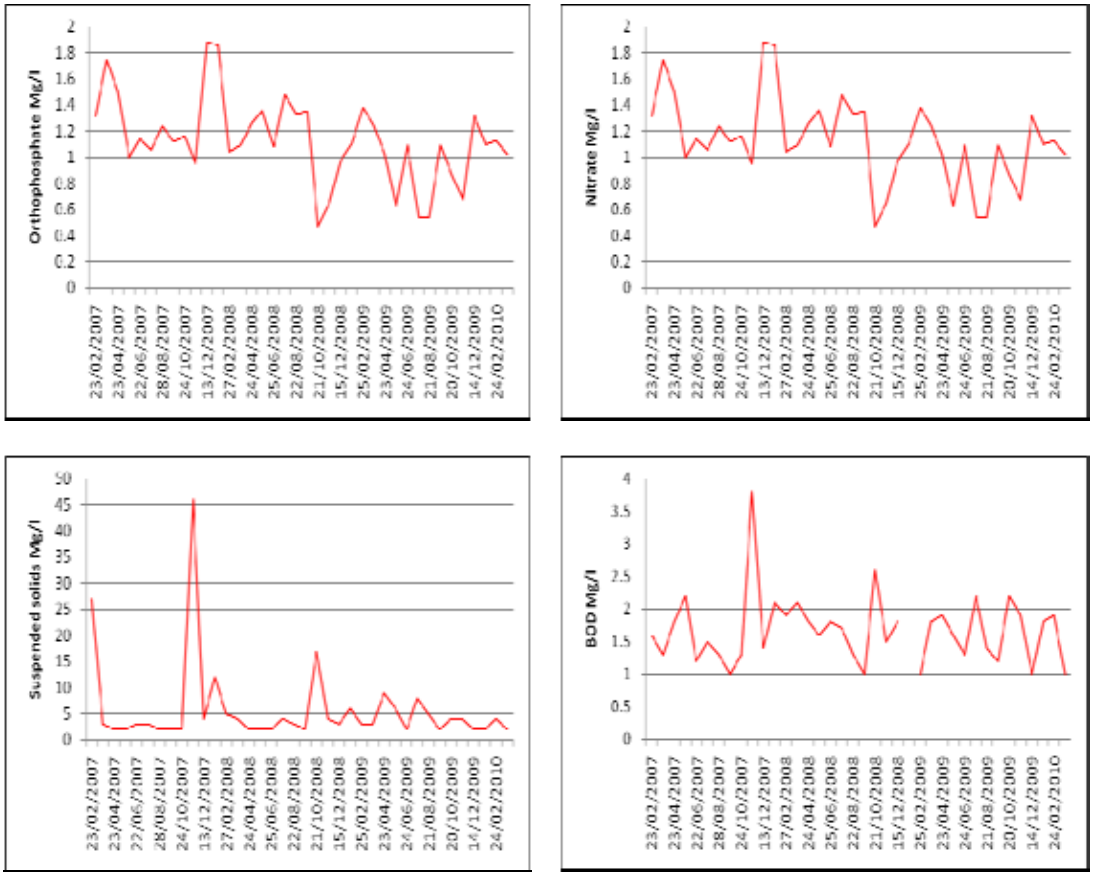

Fig 12 (a) Variance in **(a)** orthophosphate, **(b)** nitrate, **(c)** suspended solids and **(d)** biological oxygen demand from January 2007 to March 2010 (data obtain from the NIEA Water Management Unit).

Table 11 Conservation Assessment for the Tempo ASSI freshwater pearl mussel population.

Attribute	Target	Actual	Pass/Fail
Mussels			
Density	Potentially suitable habitat at capacity (or at least 10 mussel/m^2)	Three small beds; densities generally ≤0.5 mussels/m^2	Fail
Number of live individuals	No decline since most recent survey	-17.9% decrease in numbers since previous assessment (2009)	Fail
Numbers of dead shells	<1% of population	26 dead : 431 live (6.0% dead)	Fail
Age structure 1	At least 20% of population ≤65mm	None	Fail
Age structure 2	At least some mussels ≤30mm	None	Fail
Water Quality (2007-2010)			
Orthophosphate	0.005mg/l (<0.03)	0.01mg/l (range: 0.01-0.08)	Fail
Nitrate	0.125mg/l (<0.5)	1.13mg/l (range: 0.47-1.88)	Fail
Suspended solids	<10mg/l	Generally <10mg/l (max = 46)	Pass
BOD	<1.4mg/l	1.67mg/l (range: 1.00-3.80)	Fail
Substrate Condition			
Siltation	No plumes of silt when substrate kicked to 10cm depth	Plumes at all 3 sites assessed; 2 excessive	Fail
Redox measurements	Measurements <20% loss in redox value at 5cm depth	Not assessed	Unknown
Macrophytes		None	Not assessed
Filamentous algae	None (<5% cover)	Present in all section between 10-20%	Fail
Adjacent Land Use Issues		Poor fencing, cattle poaching and crossing (including broken shells) and fallen tree creating siltation	Fail
Evidence of pearl fishing	None	No exploitation evident	Pass
			OVERALL CONDITION Unfavourable declining

Owenreagh proposed ASSI

A total of 15 sections were surveyed on the Owenreagh proposed ASSI (Fig. 13). A total of 8,195 live mussels were observed (Table 12). This was the first survey of the Owenreagh and the data are to be taken as the baseline survey. A total of 59 dead shells observed. For detailed maps of each section and summary tables see Appendix 1.

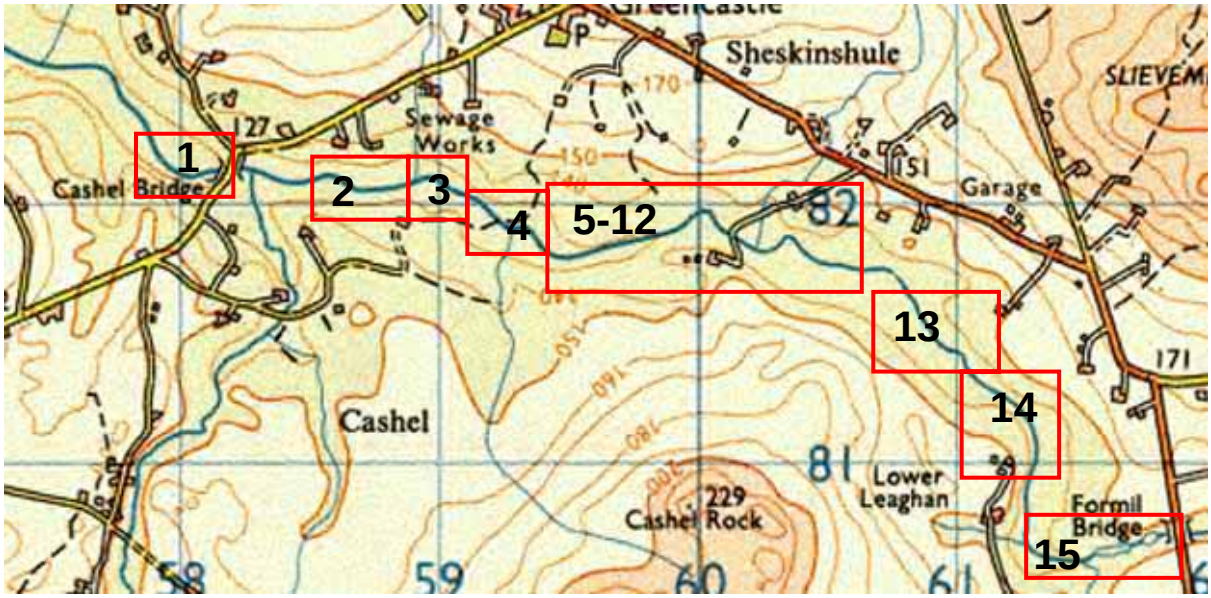

Fig. 13 Sections on the Owenreagh proposed ASSI surveyed as a baseline during 2011.

Table 12 Total numbers of live mussels recorded in each section of the Owenreagh proposed ASSI during 2011.

Section	Central Grid Reference	No. of mussels 2011
1	H 5793 8216	2
2	H 5875 8205	0
3	H 5896 8209	50
4	H 5933 8191	773
5	H 5955 8180	926
6	H 5965 8183	1,007
7	H 5979 8186	10
8	H 6002 8191	364
9	H 6027 8181	601
10	H 6041 8182	1,676
11	H 6052 8176	1,100
12	H 6058 8175	1,100
13	H 6089 8155	353
14	H 6130 8116	233
15	H 6166 8067	0
	Total	**8,195**

A total of 59 dead shells were collected during the current survey and these were used to assess age structure. The frequency distribution of shell size suggested that the population was composed predominately of aged adults (Fig. 14).

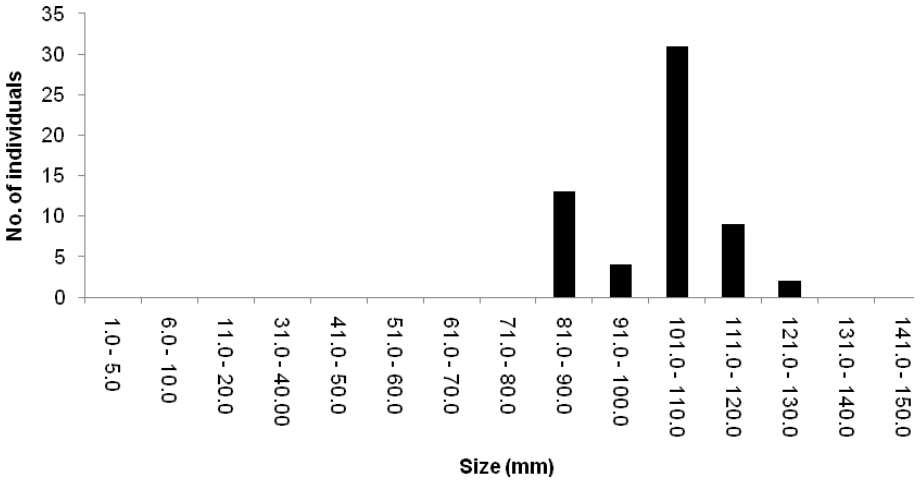

Fig 14 Frequency distribution of shell size (derived from dead shells) at the Owenreagh proposed ASSI.

Water chemistry was assessed at Drumlea Bridge (H535859) for the period of January 2007 - March 2011 (Fig. 15). Orthophosphate levels ranged from 0.01 to 0.06mg/l (mean = 0.01). Nitrate levels ranged from 0.05 to 0.75mg/l (mean = 0.43). Levels of suspended solids were generally below 10mg/l but rose above this level on three occasions up to a maximum of 54mg/l during July 2008. BOD ranged from 1.00-4.30mg/l (mean = 1.65).

A conservation assessment using criteria from Table 3 suggested that the population on the Owenreagh proposed ASSI is currently in “Unfavourable” condition. However, as this was the first baseline survey it was impossible to assess if the condition was declining. We therefore judged this assessment as “Unfavourable no change” (Table 13).

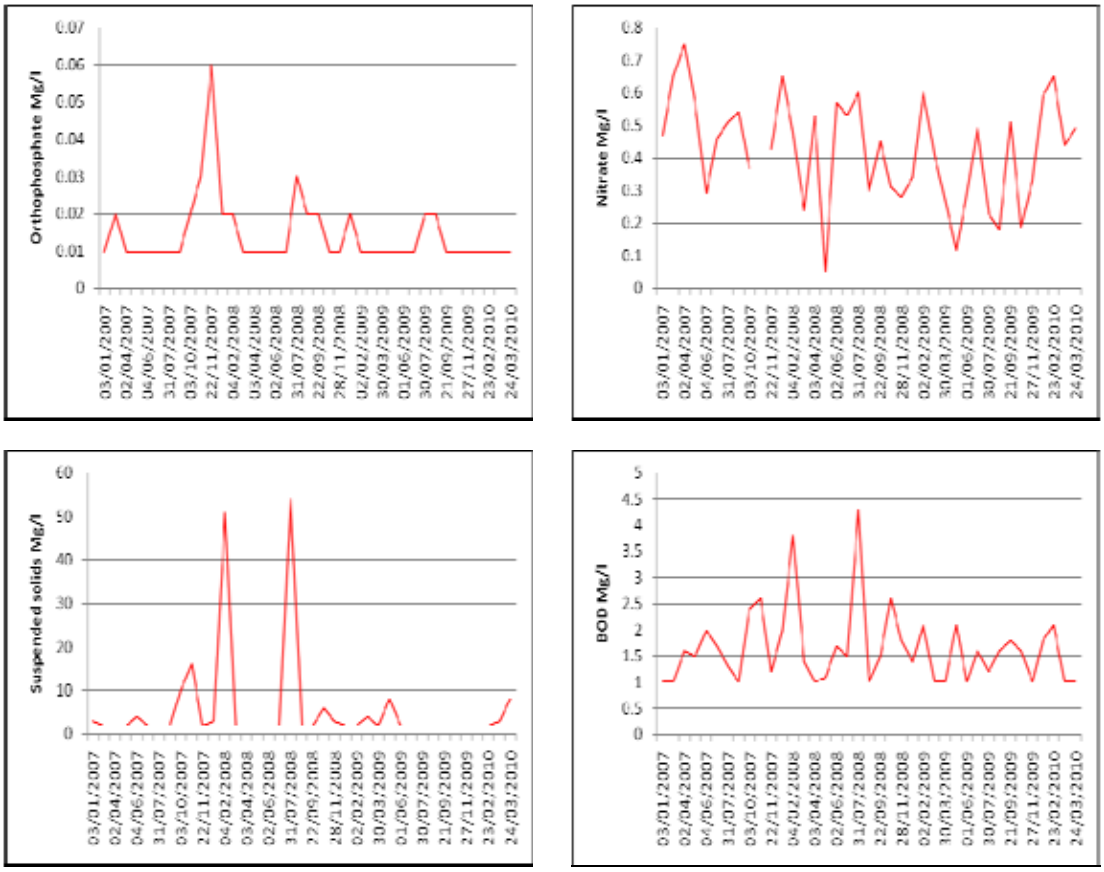

Fig 15 (a) Variance in **(a)** orthophosphate, **(b)** nitrate, **(c)** suspended solids and **(d)** biological oxygen demand from January 2007 to March 2010 (data obtain from the NIEA Water Management Unit).

Table 13 Conservation Assessment for the Owenreagh proposed ASSI freshwater pearl mussel population.

Attribute	Target	Actual	Pass/Fail
Mussels			
Density	Potentially suitable habitat at capacity (or at least 10 mussel/m^2)	Large numbers of beds throughout surveyed sections often with high numbers but densities were ≤5.5 mussel/m^2	Fail
Number of live individuals	No decline since most recent survey	First baseline survey; no previous data	Not assessed
Numbers of dead shells	<1% of population	59 dead : 8,195 live (0.72% dead)	Pass
Age structure 1	At least 20% of population ≤65mm	None	Fail
Age structure 2	At least some mussels ≤30mm	None	Fail
Water Quality (2007-2010)			
Orthophosphate	0.005mg/l (<0.03)	0.01mg/l (range: 0.01-0.06)	Fail
Nitrate	0.125mg/l (<0.5)	0.43mg/l (range: 0.05-0.75)	Fail
Suspended solids	<10mg/l	Generally <10mg/l (max = 54)	Pass
BOD	<1.4mg/l	1.65mg/l (range: 1.00-4.30)	Fail
Substrate Condition			
Siltation	No plumes of silt when substrate kicked to 10cm depth	Sediment largely boulders, cobbles and coarse grain sand. No plumes reported.	Pass
Redox measurements	Measurements <20% loss in redox value at 5cm depth	Not assessed	Unknown
Macrophytes		*Ranunculus* beds common and widepread	Not assessed
Filamentous algae	None (<5% cover)	Where present generally <10%	Fail
Adjacent Land Use Issues		Waste Water Treatment Works (WWTW) nearby, dredging present, excavations previously made, cattle poaching and crossing and poor fencing in places	Fail
Evidence of pearl fishing	None	No exploitation evident	Pass
			OVERALL CONDITION Unfavourable

Waterfoot proposed ASSI

A total of 3 sections were surveyed on the Waterfoot proposed ASSI (Fig. 16). A total of 406 live mussels were observed (Table 14). Previous surveys were not directly comparable as the area surveyed was poorly reported (Table 14). No dead shells observed. For detailed maps of each section and summary tables see Appendix 1.

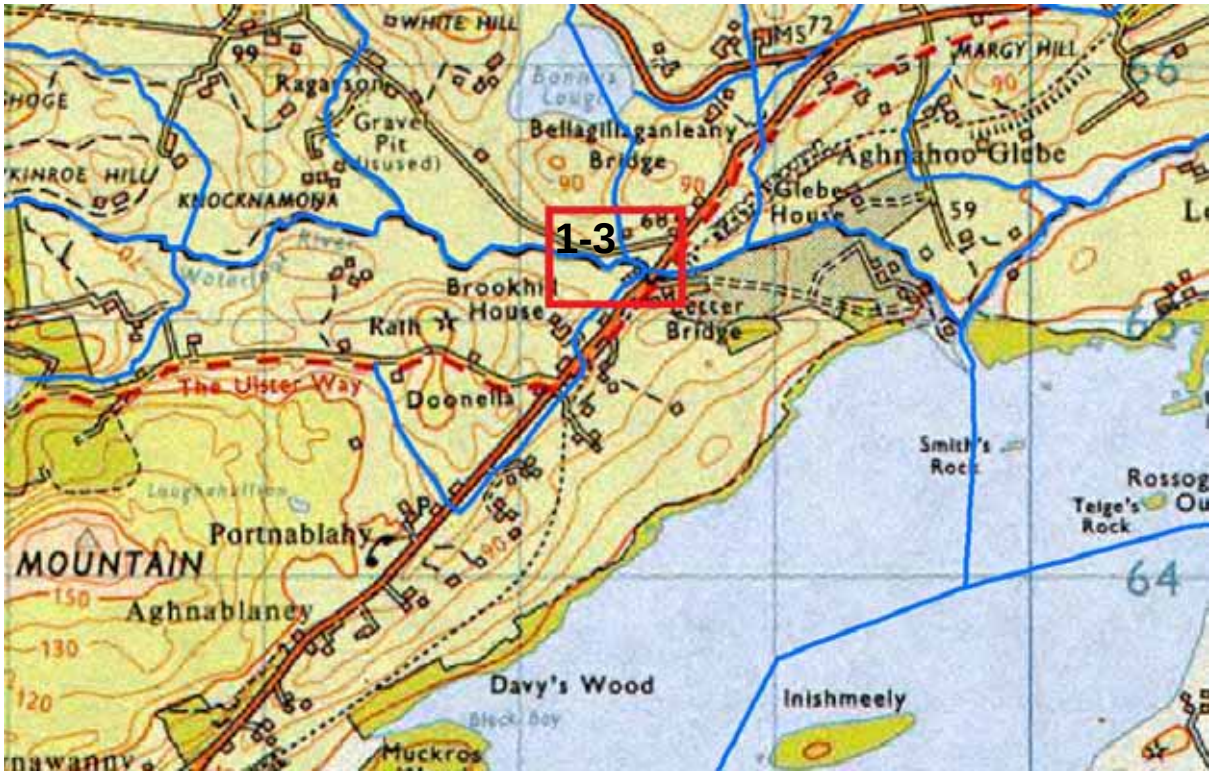

Fig. 16 Survey sections on the Waterfoot surveyed for comparison with Preston (2006).

Table 14 Total numbers of live mussels recorded in each section of the Waterfoot non-SAC in previous and the current survey.

Sections	Locations	Central Grid Reference	2006* # mussels (area surveyed)	2006* Density (mussels/m²)	2009† # mussels (area surveyed)	2009† Density (mussels/m²)	2011 # mussels (area surveyed)	2011 Density (mussels/m²)
1	Upstream of Letter Bridge	H085652	225 (unknown)	-	64 (106m²)	0.60	107	-
2	150m upstream of Letter Bridge	H084652	550 (unknown)	-	-	-	183	-
3	250m upstream of Letter Bridge	H083653	490 (unknown)	-	14 (140m²)	0.10	116	-
		Total	**1,265** (4,000m²)	**0.32**	**78** (246m²)	**0.32**	**406** (680m²)	**0.60**

NB: The areas covered are not comparable between surveyed and in some cases are unknown. However, reported estimates of density may be comparable.

* Preston (2006) - Area covered in each section was unreported, however, total count was from an area 1,000m x 4m = 4,000m².
† Wilson (2011) – Only mussel density reported. Area (m²) was back calculated. Dimensions of bed unreported.

No dead shells were recovered during the current survey. However, a sample of 57 dead shells previously collected by NIEA (provided courtesy of Tony Waterman) was used to assess age structure. The frequency distribution of shell size suggested that the population was composed predominately of aged adults (Fig. 17).

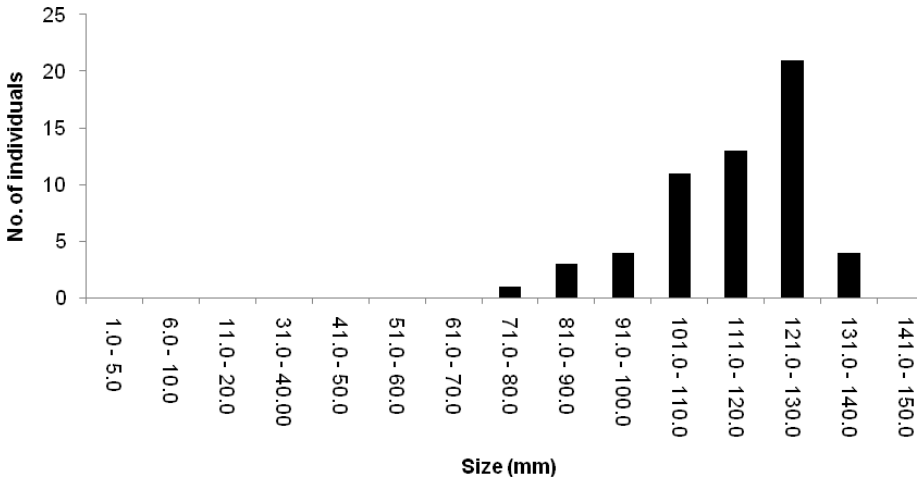

Fig 17 Frequency distribution of shell size (derived from dead shells collected) at the Waterfoot proposed ASSI.

Water chemistry was assessed at Letter Bridge (H085652) for the period of January 2007 - March 2011 (Fig. 18). Orthophosphate levels ranged from 0.01 to 0.02mg/l (mean = 0.01). Nitrate levels ranged from 0.05 to 0.21mg/l (mean = 0.09). Levels of suspended solids were consistently below 10mg/l and never rose above a maximum of 7mg/l during September 2008. BOD ranged from 1.00-2.40mg/l (mean = 1.41).

A Conservation Assessment using criteria from Table 3 suggests that the population on the Waterfoot proposed ASSI is currently “Unfavourable declining” (Table 15).

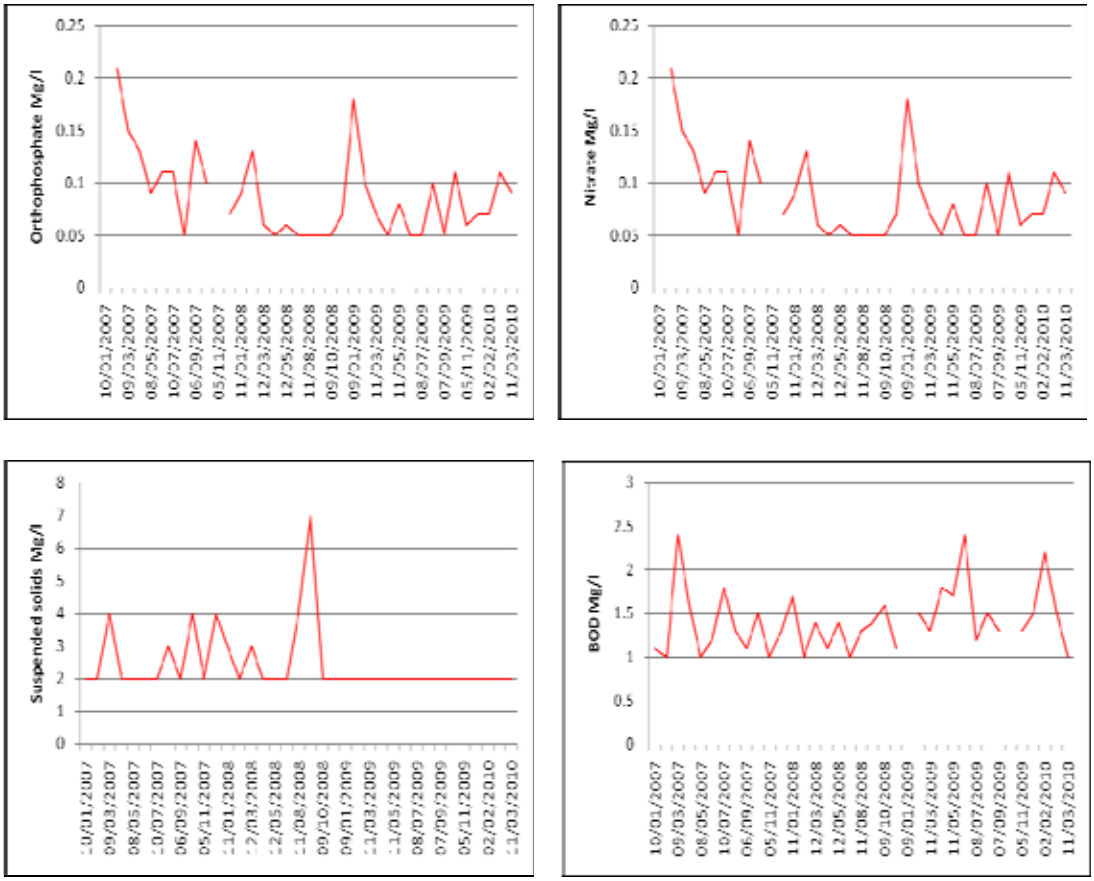

Fig 18 (a) Variance in **(a)** orthophosphate, **(b)** nitrate, **(c)** suspended solids and **(d)** biological oxygen demand from January 2007 to March 2010 (data obtain from the NIEA Water Management Unit).

Table 15 Conservation Assessment for the Waterfoot proposed ASSI freshwater pearl mussel population.

Attribute	Target	Actual	Pass/Fail
Mussels			
Density	Potentially suitable habitat at capacity (or at least 10 mussel/m^2)	Mussels at 3 sections but densities ≤0.60 mussel/m^2	Fail
Number of live individuals	No decline since most recent survey	Temporal comparisons are difficult due to varying methodologies but general evidence for decline since 2006	Fail
Numbers of dead shells	<1% of population	0 dead : 406 live (0.0% dead)	Pass
Age structure 1	At least 20% of population ≤65mm	None	Fail
Age structure 2	At least some mussels ≤30mm	None	Fail
Water Quality (2007-2010)			
Orthophosphate	0.005mg/l (<0.03)	0.01mg/l (range: 0.01-0.02)	Fail
Nitrate	0.125mg/l (<0.5)	0.09mg/l (range: 0.05-0.21)	Pass
Suspended solids	<10mg/l	Consistently <10mg/l (max = 7)	Pass
BOD	<1.4mg/l	1.41mg/l (range: 1.00-2.30)	Fail
Substrate Condition			
Siltation	No plumes of silt when substrate kicked to 10cm depth	No plumes at any section	Pass
Redox measurements	Measurements <20% loss in redox value at 5cm depth	Not assessed	Unknown
Macrophytes		None	Not assessed
Filamentous algae	None (<5% cover)	Present in all section but <10%	Fail
Adjacent Land Use Issues		None	Pass
Evidence of pearl fishing	None	No exploitation evident	Pass
			OVERALL CONDITION Unfavourable declining

DISCUSSION

A total of 12,947 freshwater pearl mussels were recorded on SAC designated rivers (Ballinderry, Owenkillew and Swanlinbar). Whilst there was a +4.1% increase in the numbers of mussels recorded, there was no significant temporal trend in abundance within designated sites and populations were judged to be stable since previous surveys during 2004/06.

Nevertheless, for all SAC rivers mean values for orthophosphate, nitrate and BOD resulted in attributes failing the current condition assessment. Only values for suspended solids passed the assessment. Overall, the current assessment was determined as “Unfavourable no change” as populations had remained stable but water chemistry conditions, whilst improved from the previous condition assessment (Killeen 2006), were still above maximum threshold values.

A total of 9,032 freshwater pearl mussels were recorded on ASSI and proposed ASSI rivers (Tempo, Owenreagh and Waterfoot). The current survey discovered a substantial population (8,195 mussels) on the Owenreagh and represented the first baseline data for this river. Numbers declined by -17.9% on the Tempo river. The Waterfoot had also been surveyed previously, however, there were difficulties in direct comparisons of individual river sections between the current survey and previous surveys. Overall, the current assessment was determined as “Unfavourable declining” on the Tempo ASSI and Waterfoot proposed ASSI and “Unfavourable” on the Owenreagh proposed ASSI as water chemistry conditions were still above maximum threshold values.

Overall, a total of 21,979 freshwater pearl mussels were recorded on six rivers throughout Northern Ireland.

ACKNOWLEDGEMENTS

This project was funded by the Northern Ireland Environment Agency (NIEA) via the Natural Heritage Research Partnership (NHRP) with *Quercus*, Queen's University Belfast. Many thanks to Tony Waterman and John Early who acted as joint NIEA Client Officers. Thanks also to Frank Mitchell, Mark Horton and Steven Ewbank for assistance in the field. We are also grateful to Dr. Conor Wilson who provided data for mussel occurrence on the Owenreagh non-SAC rivers during 2009.

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APPENDIX I – Individual site maps and data summaries

Individual maps for specific sections of each river surveyed and summary tables for results, including the total counts of mussels in each bed during the previous and current survey are provided overleaf.

Ballinderry SAC – Section #16

Location:	Downstream of Corkhill Bridge
Start Point GPS: H74218 78781	**Start Point Features**: Island in mid-channel
End Point GPS: H73704 79129	**End Point Features**:
Approximate distance (m): 470m	
Presence of fine sediments: Layer of fine sediment over substrate along margins of the channel. Silt plumes produced when substrate disturbed.	
Filamentous algae: <10%	
Total No. Live Mussels Counted 2011: 550	
No. of dead shells 2011: 21	
Issues/Comments: Some poaching of the banks by livestock.	

Ballinderry SAC - Section #16 Comparison of mussel counts during 2007 and 2011 within specific mussel beds known as section sub-units within Killeen (2007).

Section Unit	Limits	No. of mussels	
		2007	2011
A	Start point near confluence at H74218 78781 to upstream end of island at H74158 78848	155	156
B	Upstream of old Mill race H73949 78971 for 20 metres	127	121
u/s of B		-	104
C1	From 10m downstream of fence at H73835 79015 to end of tree line at H73793 79122	226	169
C2	Section continues alongside of island (u/s end at H73704 79129) to cascade c. 25m beyond.	135	
	TOTAL	**643**	**550**

Ballinderry SAC – Section #17

Location:	Downstream of Wellbrook Beetling Mill	
Start Point GPS: H75130 79230	**Start Point Features**: Cascade	
End Point GPS: H73704 79129	**End Point Features**: Wellbrook Beetling Mill Bridge	
Approximate distance (m): 140m		
Presence of fine sediments: Layer of fine sediment over substrate throughout. Silt plumes produced when substrate disturbed.		
Filamentous algae: <10%		
Total No. Live Mussels Counted 2011: 106		
No. of dead shells 2011: 11		
Issues/Comments: Some stock access to banks and channel.		

Ballinderry SAC - Section #17 Comparison of mussel counts during 2007 and 2011 within specific mussel beds known as section sub-units within Killeen (2007).

Section Unit	Limits	No. of mussels	
		2007	2011
	TOTAL (entire Section)	**113**	**106**

Ballinderry SAC – Sections #20-22

Location:	Upstream of Aughlish Bridge to the bridge.
Start Point GPS: H78703 78195	**Start Point Features**: d/s end of concrete plinth beneath Auglish
End Point GPS: H77521 78450	**End Point Features**: Riffle below Kildress House
Approximate distance (m): 470m	
Presence of fine sediments: Layer of silt over substrate throughout especially in slower reaches. Silt plumes produced on disturbance of the substrate.	
Filamentous algae: <10%	
Total No. Live Mussels Counted 2011: 190	
No. of dead shells 2011: 35	
Issues/Comments: Greater levels of silt throughout. Stock access a particular problem and erosion of banks due to livestock poaching.	

Ballinderry SAC - Section #20-22 Comparison of mussel counts during 2007 and 2011 within specific mussel beds known as section sub-units within Killeen (2007).

Section Unit	Limits	No. of mussels	
		2007	2011
A	From start point to weir at H78693 78197	10	5
B	To next weir at H78689 78202	2	4
C	To riffle at H78651 78237	16	21
D	To large boulders at H78616 78253	41	27
E	To weir/rocks at H78522 78238	0	0
F	To bedrock weir by gravel pit at H78100 78240	109	82
G	To fisherman's hut at H77751 78360	28	30
H	To dead tree on north bank at H77712 78355	13	7
I	To end of woodland at H77655 78368	10	13
J	To riffle below Kildress House at H77521 78450	4	1
	TOTAL	**233**	**190**

Owenkillew SAC – Section #12

Location:	Upstream of Crouck Bridge.
Start Point GPS: H62595 83641	**Start Point Features**: Crouck Bridge
End Point GPS: H63198 83647	**End Point Features**: Field boundary
Approximate distance (m): 800m - discontinuous	
Presence of fine sediments: Some silt present especially in slower water. Some plumes of silt when substrate disturbed but quickly dispersed.	
Filamentous algae: <5%	
Total No. Live Mussels Counted 2011: 2391	
No. of dead shells 2011: 142	
Issues/Comments: Poaching of the bank by livestock and severe erosion by recent floods. Lack of bankside fencing due to collapse of banks by flooding. Stranding of a large number of mussels washed down by recent flood events along the channel margins. Several mussels in <10cm depth of water and in danger of drying out.	

Owenkillew SAC - Section #12 Comparison of mussel counts during 2007 and 2011 within specific mussel beds known as section sub-units within Killeen (2007).

Section Unit	Limits	No. of mussels	
		2007	2011
A	Under Crouck Bridge	39	59
B	U/s end of Crouck Bridge to willow on N bank at H62623 83645	32	43
C	To sycamore on N bank at H62628 83641	6	2
D	To sycamore trunk + willow at H62659 83626	7	5
E	To willow at H62677 83615 (last tree on north bank)	7	4
F	To large dark boulder on N bank at H62706 83603	3	5
	Gap		
G	From willow on S bank at H62787 83509	24	412
H	To the upstream willow of 2 willows on S bank. The deep ditch immediately above the willow is at H62815 83543	18	
I	To top of riffle at H62826 83557	10	
J	To barbed wire fence on S bank at H62846 83592	53	71
K	To deep ditch and barbed wire fence on S bank at H62875 83680	17	62
	Gap		
L	Downstream tip of boulder at H63104 83777 to H63112 83776	408	1728
M	Upstream to field boundary at H63198 83749	200+	
TOTAL		**824+**	**2391**

Owenkillew SAC – Multiple mussel beds at point transects

Owenkillew SAC – Multiple mussel beds at points Comparison of mussel counts during 2004 and 2011 at specific points.

Bed No.	Central Grid Ref.	Bed Length (m)	No. of mussels	
			2004	**2011**
A1	H61458466	10	87	5
A2	H61428469	25	100	42
A3	H61448463	15	100	19
A4	H62038391	30	210	170
A5	H62188388	30	?	220
A6	H62338357	20	368	412
A7	H63048376	45	952	741
A8	H63108377	20	1101	987
A9	H63288376	66	1536	1081
A10	H63338376	20	172	168
A11	H63418381	50	1027	842
A12	H63518380	70	264	243
A13	H63568384	10	240	198
B1	H6260 8365	-	15	59
B2	H6288 8369	-	42	71
B3	H6289 8371	-	38	29
B4	H6296 8375	-	15	33
B5	H6315 8377	-	18	15
B6	H6317 8377	-	26	45
B7	H6318 8376	-	41	26
B8	H6322 8374	-	28	61
		TOTAL	**6380**	**5467**

Owenkillew SAC – Multiple mussel beds at line transects

Owenkillew SAC – Multiple mussel beds at transects Comparison of mussel counts during 2004 and 2011 at 1x50m transects previously surveyed by NIEA.

Transect No.	D/S Grid ref	U/S Grid ref	No. Mussels 2004	No. Mussels 2011
T1	IH61498461	H61538458	205	189
T2	IH61708438	H61718432	451	374
T3	IH62888369	H62918373	10	21
T4	IH63388382	H63368381	61	32
		Total	**727**	**616**

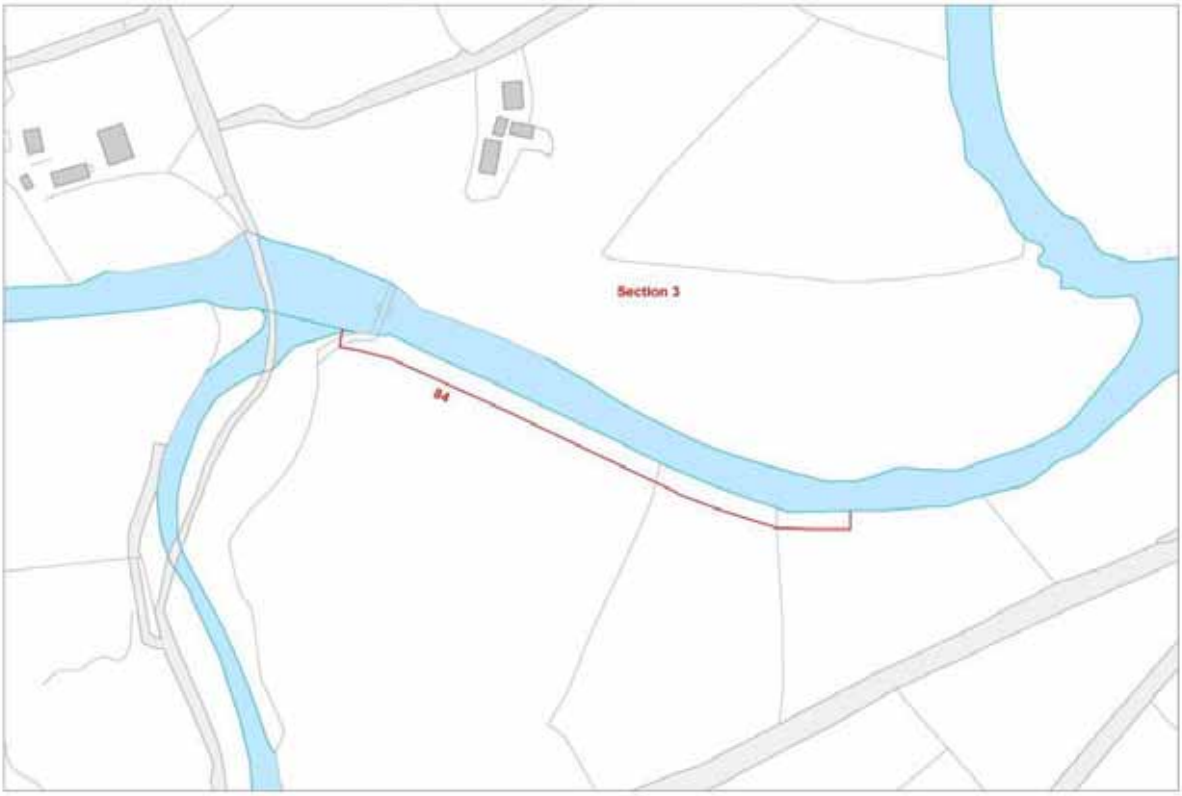
Swanlinbar SAC – Section #2

Location:	Upstream of Glasdrumman Bridge
Start Point GPS: H22144 28697	**Start Point Features**: Ford
End Point GPS: H22017 28848	**End Point Features**: Field boundary on north (east) bank
Approximate distance (m): 450	
Presence of fine sediments: None	
Filamentous algae: Less than 10% cover overall	
Total No. Live Mussels Counted 2011: 1,396	
No. of dead shells 2011: 41	
Issues/Comments: Stock access and vehicle access at ford where mussels are known to be present immediately upstream. Use of tar to paint wooden footbridge. Area known to have been fished for pearl mussel in the distant past (land owner pers. comm.).	

Swanlinbar SAC - Section #2 Comparison of mussel counts during 2007 and 2011 within specific mussel beds known as section sub-units within Killeen (2007).

Section sub-unit	Limits	No. of mussels			
		2007		2011	
		N½	S½	N½	S½
A	Ford to stepping stones at H22113 28688	0	58	0	45
B	Stepping stones to footbridge at H22083 28688	3	57	68	37
C	To tree leaning into river at H22066 28687	54	0	61	0
D	To field boundary (on S side) at H22035 28681	29	64	45	88
E	To field boundary and gate (on S side) at H21989 28714	16	32	8	51
F	To big ash on north bank at H21998 28747	52	0	63	0
G	To opposite field boundary	37	0	21	0
H	To alder tree on north bank	42	0	40	0
I	To double-trunked ash (on N side) at H21994 28757	29	391	143	391
J	To field boundary (on N side) at H22007 28788	13	32	18	56
K	To field boundary (on N side) at H22017 28848	141	62	203	58
	TOTAL	**1,112**		**1,396**	

Swanlinbar SAC – Section #3



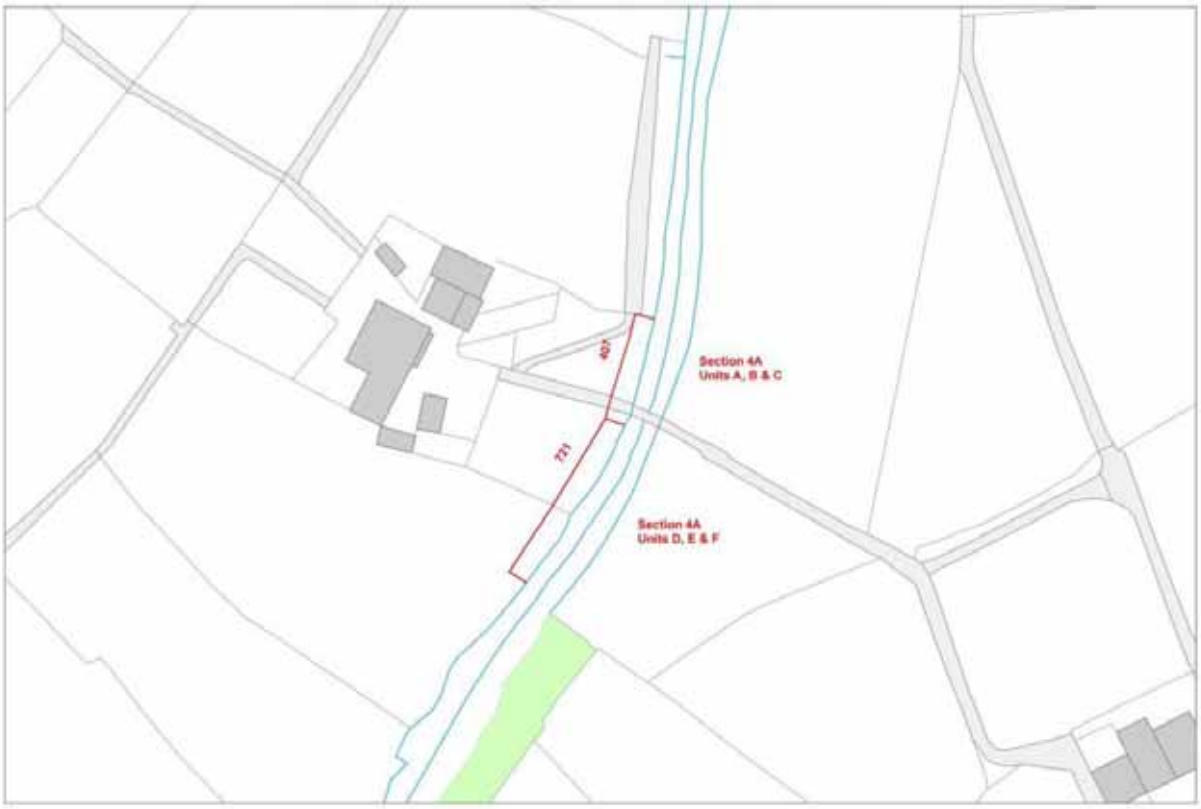
Summary table

Location:	Downstream of Glassdrumman Bridge
Start Point GPS: H22810 28813	**Start Point Features**: Hazel tree on south bank
End Point GPS: H73704 79129	**End Point Features**: Owengarr River confluence
Approximate distance (m): 300	
Presence of fine sediments: Few fines observed	
Filamentous algae: Less than 10% cover overall	
Total No. Live Mussels Counted 2011: 84	
No. of dead shells 2011: 6	
Issues/Comments: Channel substrate clean and very little silt or filamentous algae present. Some stock access from eroded banks.	

Swanlinbar SAC - Section #3 Comparison of mussel counts during 2007 and 2011 within specific mussel beds known as section sub-units within Killeen (2007).

Section Unit	Limits	No. of mussels	
		2007	2011
A	Hazel tree to field boundary at H22752 28828	0	6
B	To sycamore at H22694 28861	41	57
C	To old footbridge at H22652 28872	12	19
D	To Owengarr confluence	0	2
	TOTAL	**53**	**84**

Swanlinbar SAC – Section #4a



Location:	Upstream and downstream of the Ulster Way bridge at Drumroosk
Start Point GPS:	**Start Point Features**: Field boundary downstream of bridge
End Point GPS: H23403 29551	**End Point Features**: Stepping Stones
Approximate distance (m): 300	
Presence of fine sediments: Few fines observed	
Filamentous algae: Less than 10% cover overall	
Total No. Live Mussels Counted 2011: 726	
No. of dead shells 2011: 32	
Issues/Comments: Channel substrate clean and very little silt or filamentous algae present.	

Swanlinbar SAC - Section #4a Comparison of mussel counts during 2007 and 2011 within specific mussel beds known as section sub-units within Killeen (2007).

Section Unit	Limits	No. of mussels	
		2007	2011
A & B	Field boundary at H23473 29820 to centre point of riffle at H23464 29785	369	402
C	Riffle to bridge at H23467 29669	0	5
D	From bridge to top of riffle	45	177
E	To field boundary on south side	84	89
F	To stepping stones at H23403 29551 567	567	455
	TOTAL	**1,065**	**1,128**

Swanlinbar SAC – Section #4b

Location:	Upstream and downstream of the Ulster Way Bridge at Drumroosk
Start Point GPS: H23403 29551	**Start Point Features**: Stepping stones
End Point GPS: H23280 29474	**End Point Features**: Field boundary
Approximate distance (m): 300	
Presence of fine sediments: Few fines observed except in slower sections of water.	
Filamentous algae: Less than 15% cover overall	
Total No. Live Mussels Counted 2011: 644	
No. of dead shells 2011: 18	
Issues/Comments: Channel substrate mostly clean with little silt or filamentous algae present.	

Swanlinbar SAC - Section #4b Comparison of mussel counts during 2007 and 2011 within specific mussel beds known as section sub-units within Killeen (2007).

Section Unit	Limits	No. of mussels	
		2007	2011
A	Immediately upstream of steeping stones	12	10
B	To sycamore on north bank at H23369 29551	30	41
C	To next sycamore on north bank	6	10
D	To field boundary at H23356 29540	63	50
E	To field boundary at H23356 29540	101	85
F	To large ash at H23312 29510	184	169
G	To large ash at H23312 29510	63	76
H	To drain at H23298 29503	80	105
I	To field boundary at H23280 29474	145	98
	TOTAL	**684**	**644**

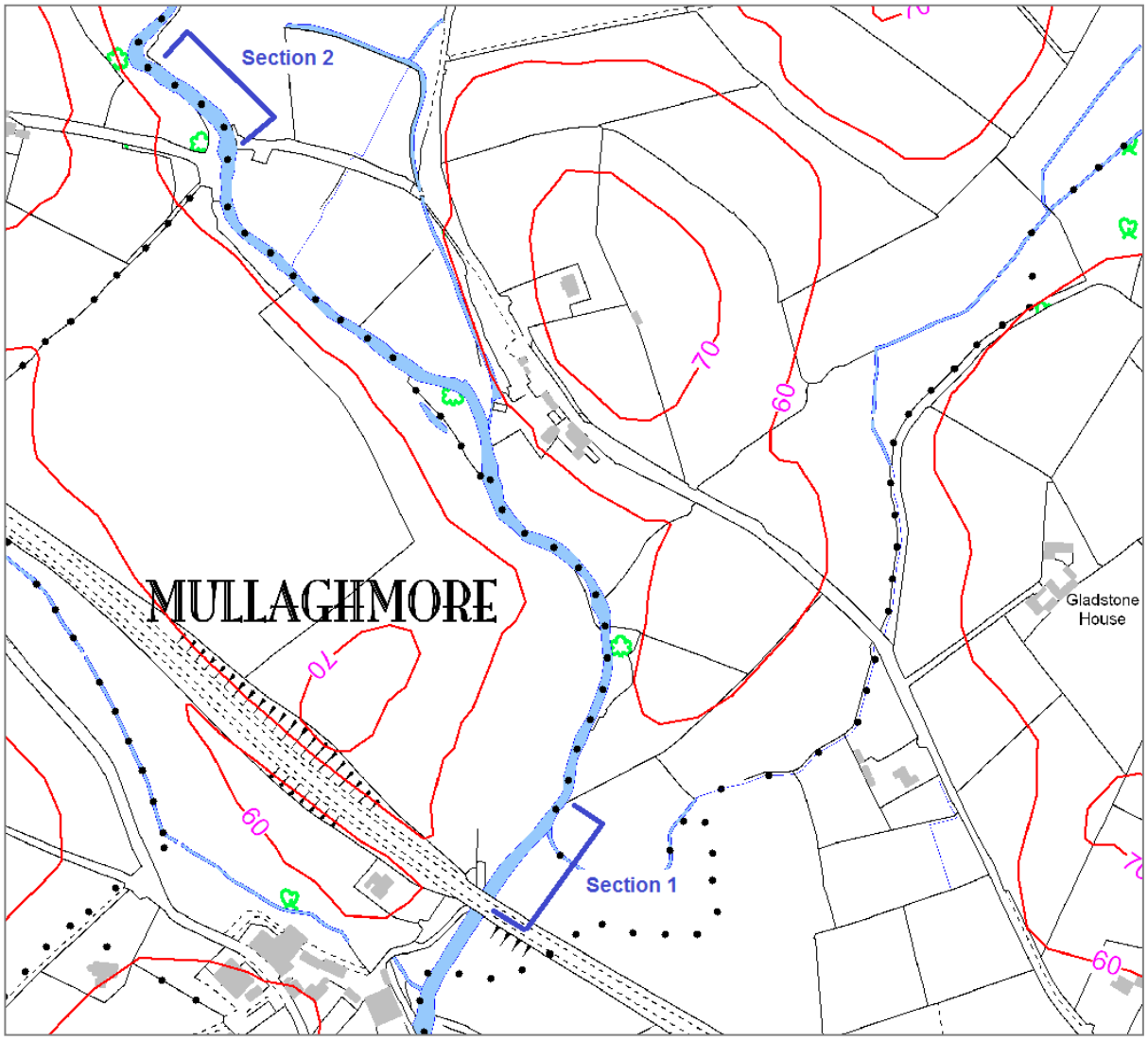
Swanlinbar SAC – Section #5

Location:	Downstream of Stragowna Bridge	
Start Point GPS: H23862 30631		**Start Point Features**: Field boundary on south bank just below downstream end of narrow island
End Point GPS: H24043 30675		**End Point Features**: Large alder on south bank
Approximate distance (m): approx 300		
Presence of fine sediments: Fines observed in slower sections of water.		
Filamentous algae: Some filamentous algae present in slower sections of river.		
Total No. Live Mussels Counted 2011: 375		
No. of dead shells 2011: 14		
Issues/Comments: Channel substrate silty with some filamentous algae present. Cattle trampling of banks severe in areas and access to the channel.		

Swanlinbar SAC - Section #5 Comparison of mussel counts during 2007 and 2011 within specific mussel beds known as section sub-units within Killeen (2007).

Section Unit	Limits	No. of mussels			
		2007		2011	
		N½	S½	N½	S½
A	Boundary hedge on bend on south bank at H23862 30631 to alder tree on south bank	7	10	15	11
B	To alder tree on south bank	39	0	25	0
C	To ash and alder on south bank	20	0	31	0
D	To old hawthorn at H23900 30634	24	0	5	0
E	To large, old willow (2 trunks) on south bank	0	57	0	69
F	To next willow on south bank	0	34	0	21
G	To hawthorn on south bank mid-channel	20		14	
H	To large sycamore on north bank	55	0	52	2
I	To willow on north bank	0	6	2	9
J	Bend section	5	66	1	71
K	Bend to single hawthorn on north bank	0	36	0	28
L	To large alder on south bank at H24043 30675	0	16	2	17
TOTAL		**395**		**375**	

Tempo ASSI – Sections #1-2



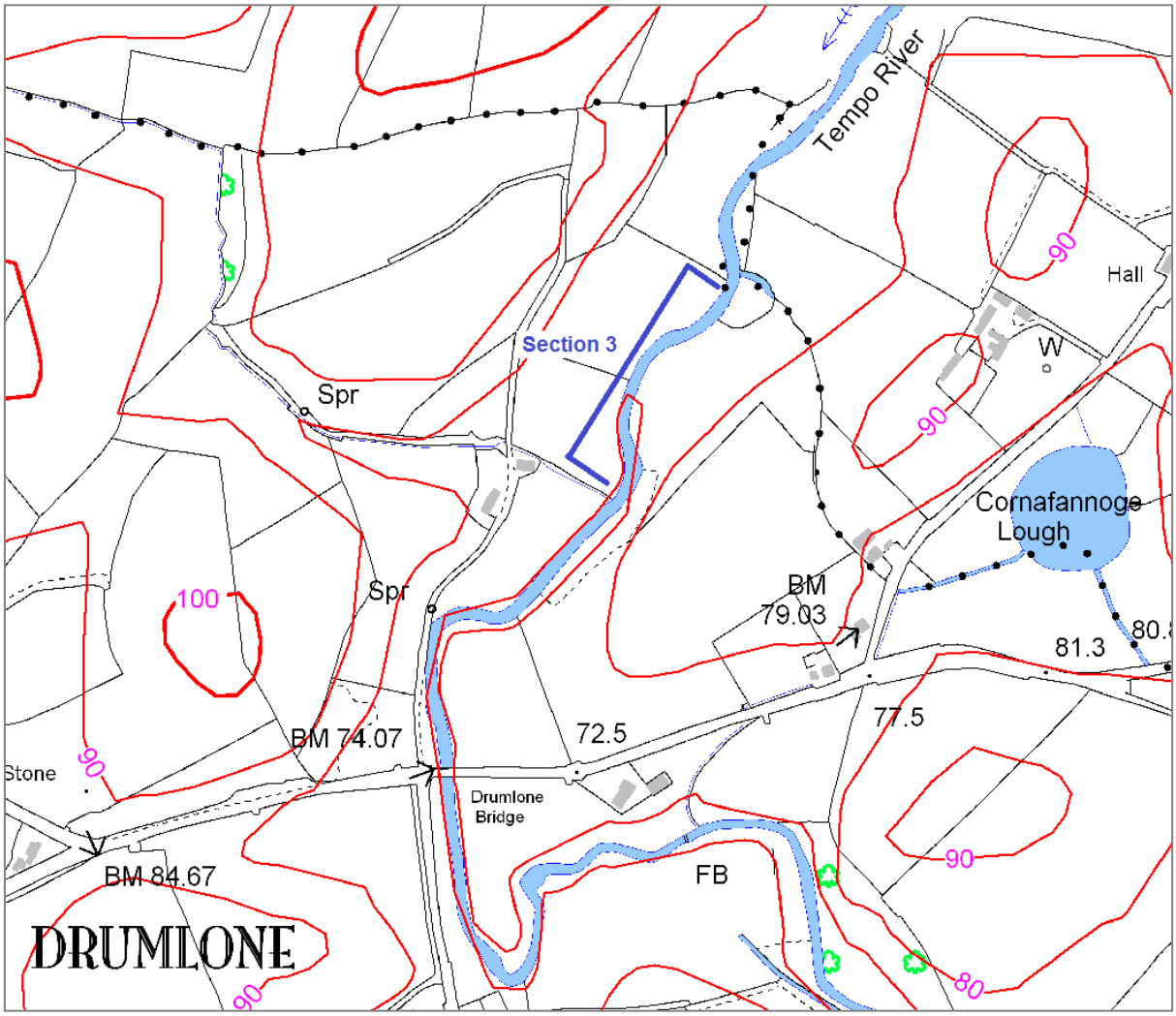
Tempo ASSI – Sections #1

Location:	A4 Road Bridge
Start Point GPS: H 3420 3925	**Start Point Features**: 5m downstream of A4 road bridge
End Point GPS:	**End Point Features**: Confluence of drain
Approximate distance (m): 80m	
Presence of fine sediments: Excessive plume from bed	
Filamentous algae: 20%	
Total No. Live Mussels Counted 2011: 125	
No. of dead shells 2011: 14	
Issues/Comments: Very poor fences along both banks. Cattle cross river at the mouth of the drain. Four broken shells found – probably the result of cattle trampling	

Tempo ASSI – Sections #2

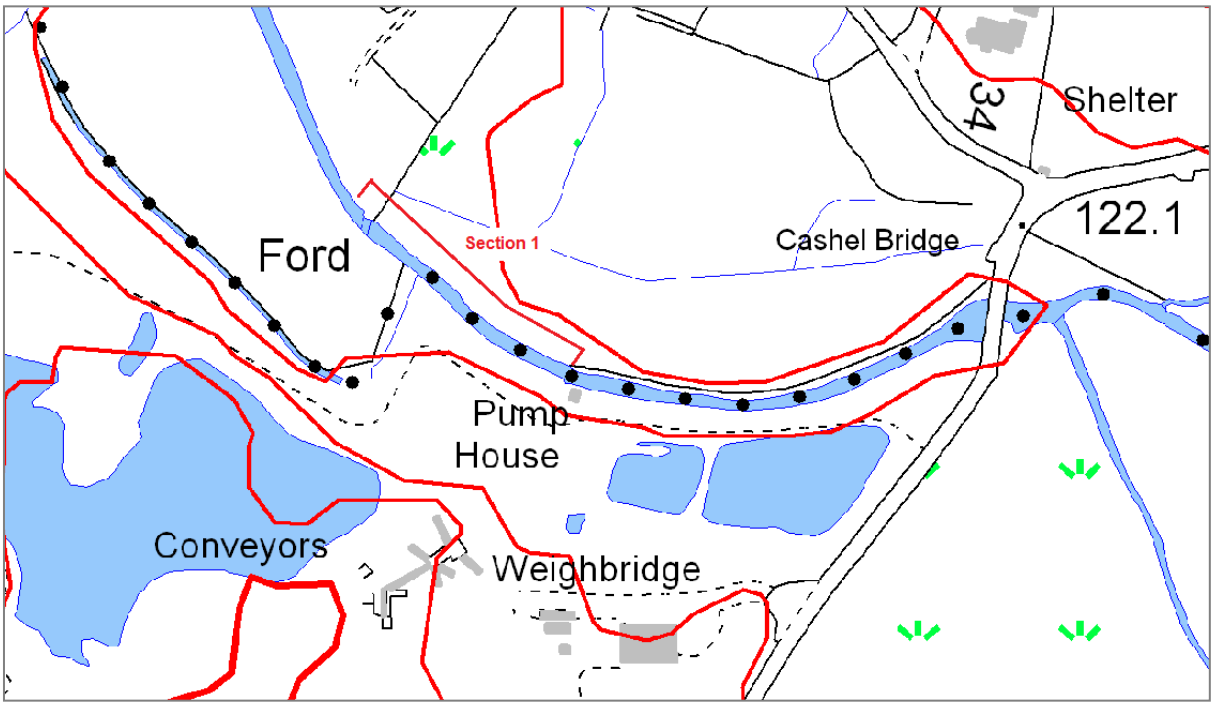
Location:	Old Coach Road ford	
Start Point GPS: H 3395 3975		**Start Point Features**: 10m downstream of Old Coach Road ford
End Point GPS:		**End Point Features**: Riffle upstream of large alder on left bank
Approximate distance (m): 80m		
Presence of fine sediments: Excessive silt plume		
Filamentous algae: 20%		
Total No. Live Mussels Counted 2011: 162		
No. of dead shells 2011: 6		
Issues/Comments: River is tree-lined and well fenced on both banks. Fallen tree should be removed as floods are scouring the river bed and exposing underlying clay. This will be causing further siltation downstream.		

Tempo ASSI – Sections #3



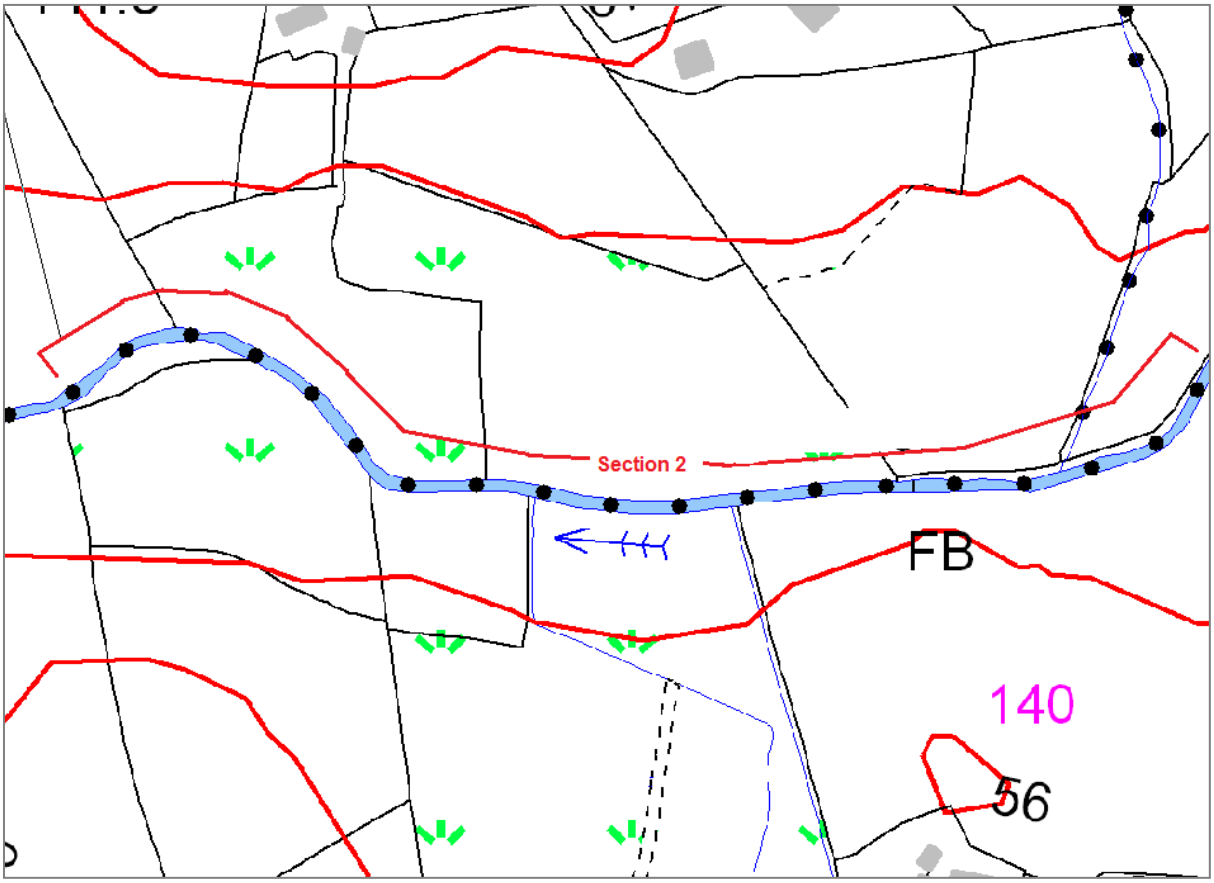
Location:	Upstream of Drumglone Bridge
Start Point GPS: H 335 4275	**Start Point Features**: Tributary entering from right bank
End Point GPS:	**End Point Features**: Fallen willows on right bank
Approximate distance (m): 80m	
Presence of fine sediments: Small plume from bed	
Filamentous algae: <10%	
Total No. Live Mussels Counted 2011: 144	
No. of dead shells 2011: 6	
Issues/Comments: Right bank unfenced where a there is a dairy cow paddock. Left bank well fenced	

Owenreagh proposed ASSI – Section #1



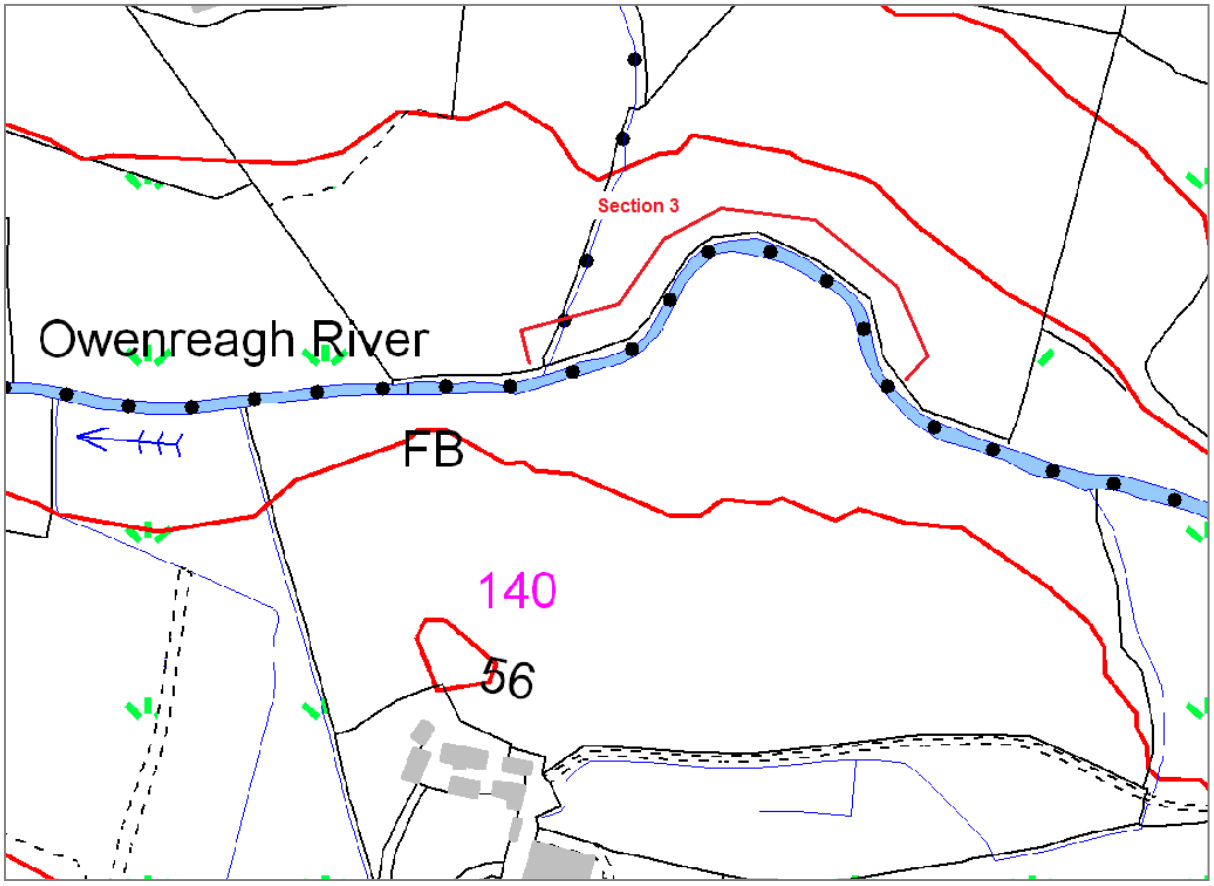
Location:	
Start Point GPS: H5800 8210	**Start Point Features**: Upstream from pump house
End Point GPS: H5791 8218	**End Point Features**: Downstream from ford
Approximate distance (m): 120m	
Presence of fine sediments: Cobble, boulder and coarse sand	
Filamentous algae: 0	
Total no. live mussels during 2011: 2	**Estimated mussels density:** 0.003 mussels/m^2
No. of dead shells 2011: 0	
Issues/Comments: Sparse *Ranunculus*. Substrate looks suitable for mussels. No signs of pressure from the adjacent quarry. Good density of 0+ salmon observed below spawning ford.	

Owenreagh proposed ASSI – Section #2



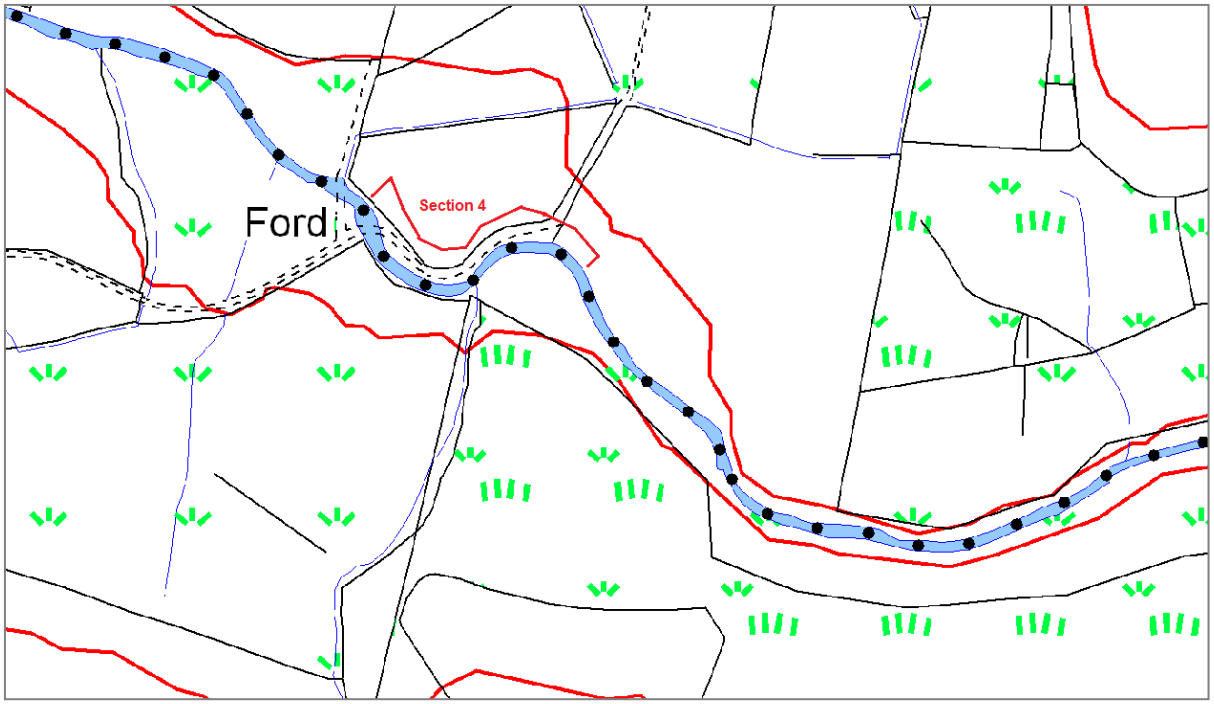
Location:	
Start Point GPS: H5892 8209	**Start Point Features**:
End Point GPS: H5851 8209	**End Point Features**:
Approximate distance (m): 200m	
Presence of fine sediments: Cobble, boulder, bedrock and sand	
Filamentous algae: 10%	
Total no. live mussels during 2011: 0	**Estimated mussels density:** 0 mussels/m^2
No. of dead shells 2011: 3	
Issues/Comments: Bedrock has been dredged along this stretch. Greencastle WWTW discharges into a tributary just upstream of this site.	

Owenreagh proposed ASSI – Section #3



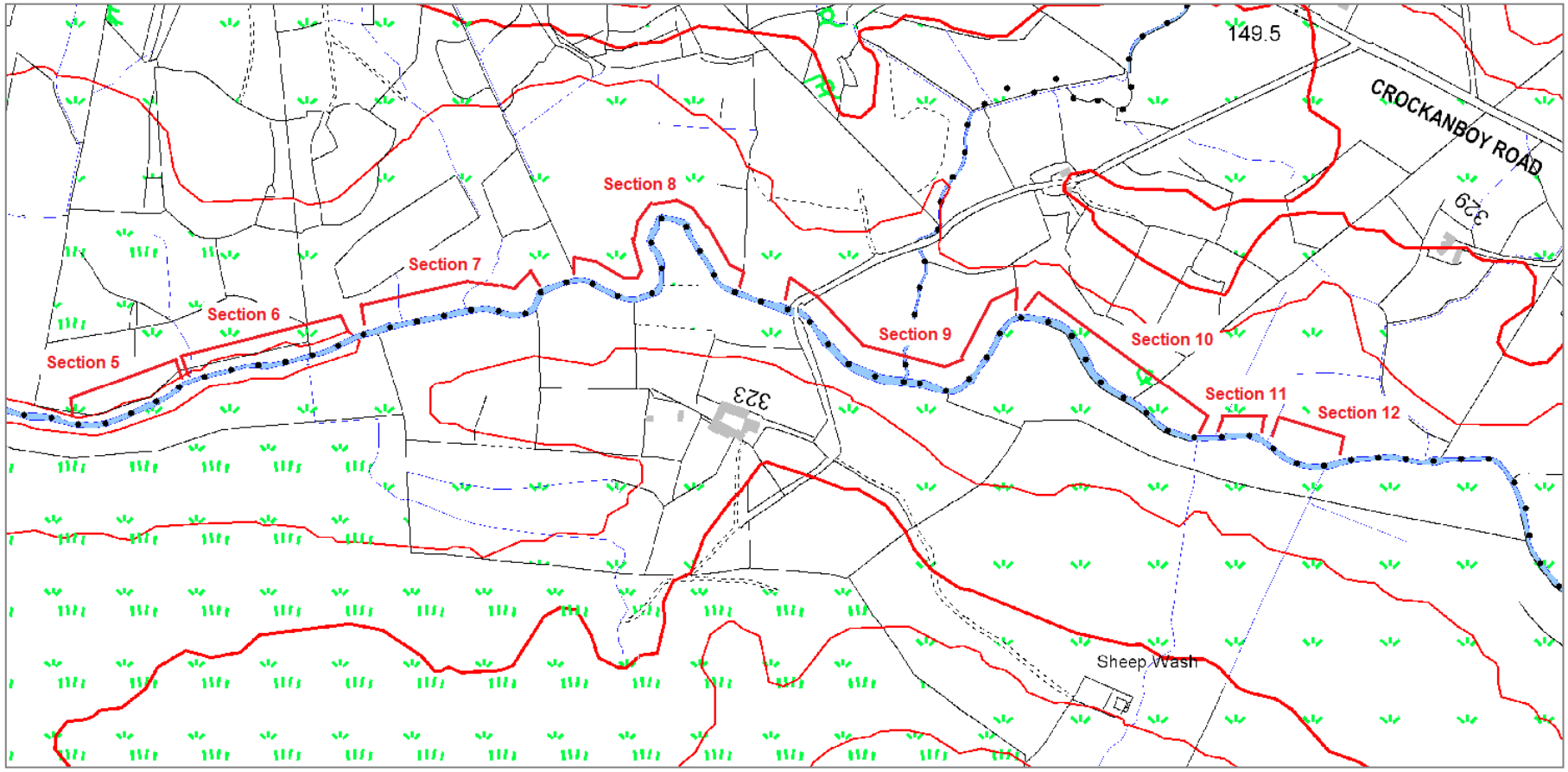
Location:	
Start Point GPS: H5901 8205	**Start Point Features**: Upstream of boulders in main channel
End Point GPS: H5886 8205	**End Point Features**: Downstream of confluence with burn
Approximate distance (m): 50m	
Presence of fine sediments: Cobble, boulder and sand	
Filamentous algae: None recorded	
Total no. live mussels during 2011: 50	**Estimated mussels density:** 0.25 mussels/m^2
No. of dead shells 2011: 0	
Issues/Comments: *Ranunculus* present. Mussels are dense along right (north) bank. The influence of the WWTW appears to have affected the mussel population downstream of the receiving burn.	

Owenreagh proposed ASSI – Section #4



Location:	
Start Point GPS: H5933 8188	**Start Point Features**:
End Point GPS: H5922 8193	**End Point Features**: Ford
Approximate distance (m): 90m	
Presence of fine sediments: Cobble, boulder and coarse grain	
Filamentous algae: None recorded	
Total no. live mussels during 2011: 773	**Estimated mussels density:** 2.17 mussels/m^2 (10.0 mussels/m^2 in *Ranunculus* beds)
No. of dead shells 2011: 2	
Issues/Comments: 573 in channel and 200 estimated in *Ranunculus* bed. Repaired fence along left bank. New fence on right bank at D/S end. No fence along much of right bank. Some excavation of the river bed here recently. No dead mussels observed in spoil.	

Owenreagh proposed ASSI – Sections #5-12



Owenreagh proposed ASSI – Sections #5

Location:	
Start Point GPS: H5958 8181	**Start Point Features**: Uptream from large patch of weed
End Point GPS: H5948 8177	**End Point Features**: At stone wall on northern bank downstream of willow
Approximate distance (m): 100m	
Presence of fine sediments: Cobble, coarse grain sand & boulders	
Filamentous algae: None recorded	
Total no. live mussels during 2011: 926	**Estimated mussels density:** 3.33 mussels/m^2
No. of dead shells 2011: 3	
Issues/Comments: *Ranunculus* present. This stretch has been allowed to close in to its natural 3 metre width since the fences were erected.	

Owenreagh proposed ASSI – Sections #6

Location:	
Start Point GPS: H5974 8185	**Start Point Features**: Riffle section
End Point GPS: H5959 8181	**End Point Features**: Downstream of deep pool
Approximate distance (m): 175m	
Presence of fine sediments: Cobble, coarse grain sand	
Filamentous algae: None recorded	
Total no. live mussels during 2011: 1007	**Estimated mussels density:** 3.33 mussels/m^2
No. of dead shells 2011: 4	
Issues/Comments: *Ranunculus* present. Buffer strips grow sedge grass, banks are stable and mussels are most dense on right (north) side of the channel. Good fences set 10 metres from river bank along both sides.	

Owenreagh proposed ASSI – Sections #7

Location:	
Start Point GPS: H5991 8189	**Start Point Features**: Upsteam of pool
End Point GPS: H5975 8185	**End Point Features**: Downstream of pool
Approximate distance (m): 220m	
Presence of fine sediments: Boulder, cobble and bedrock	
Filamentous algae: None recorded	
Total no. live mussels during 2011: 10	**Estimated mussels density:** 0.015 mussels/m^2
No. of dead shells 2011: 4	
Issues/Comments: Mussel beds are absent here as bedrock predominates. Repaired fence ends on left side at pole across the river. No fence upstream. Poor fence on right bank.	

Owenreagh proposed ASSI – Sections #8

Location:	
Start Point GPS: H6008 8189	**Start Point Features**: Downstream of bridge
End Point GPS: H5994 8190	**End Point Features**: Large expanse of bedrock
Approximate distance (m): 600m	
Presence of fine sediments: Boulder, bedrock, cobble and sand	
Filamentous algae: None recorded	
Total no. live mussels during 2011: 364	**Estimated mussels density:** 0.152 mussels/m^2
No. of dead shells 2011: 7	
Issues/Comments: *Ranunculus* present. Mussel beds re-occur upstream around the right side of a bend. Substrate has been removed from this pool {at some pines}. No shells observed in spoil.	

Owenreagh proposed ASSI – Sections #9

Location:	
Start Point GPS: H6034 8187	**Start Point Features**: Upstream of bend in channel
End Point GPS: H6013 8188	**End Point Features**: Bridge
Approximate distance (m): 300m	
Presence of fine sediments: Boulder, cobble, bedrock and sand	
Filamentous algae: None recorded	
Total no. live mussels during 2011: 601	**Estimated mussels density:** 0.5 mussels/m^2
No. of dead shells 2011: 4	
Issues/Comments: The fence on the right bank from the bridge up to the burn is poor. Fences are good on the left bank and on the right bank upstream of burn. Mussel beds are dense upstream of the bedrock within stretches 8 & 9.	

Owenreagh proposed ASSI – Sections #10

Location:	
Start Point GPS: H6050 8176	**Start Point Features**:
End Point GPS: H6035 8187	**End Point Features**:
Approximate distance (m): 180m	
Presence of fine sediments: Cobble and coarse sand	
Filamentous algae: None recorded	
Total no. live mussels during 2011: 1,676	**Estimated mussels density:** 5.55 mussels/m^2
No. of dead shells 2011: 6	
Issues/Comments: *Ranunculus* present. Good fence along left bank. Very poor fence on right bank at upstream end where improved grassland starts. This stretch holds the most dense mussel colonies in the Owenreagh. Hand searching revealed that there as many mussels in the *Ranunculus* beds as between them.	

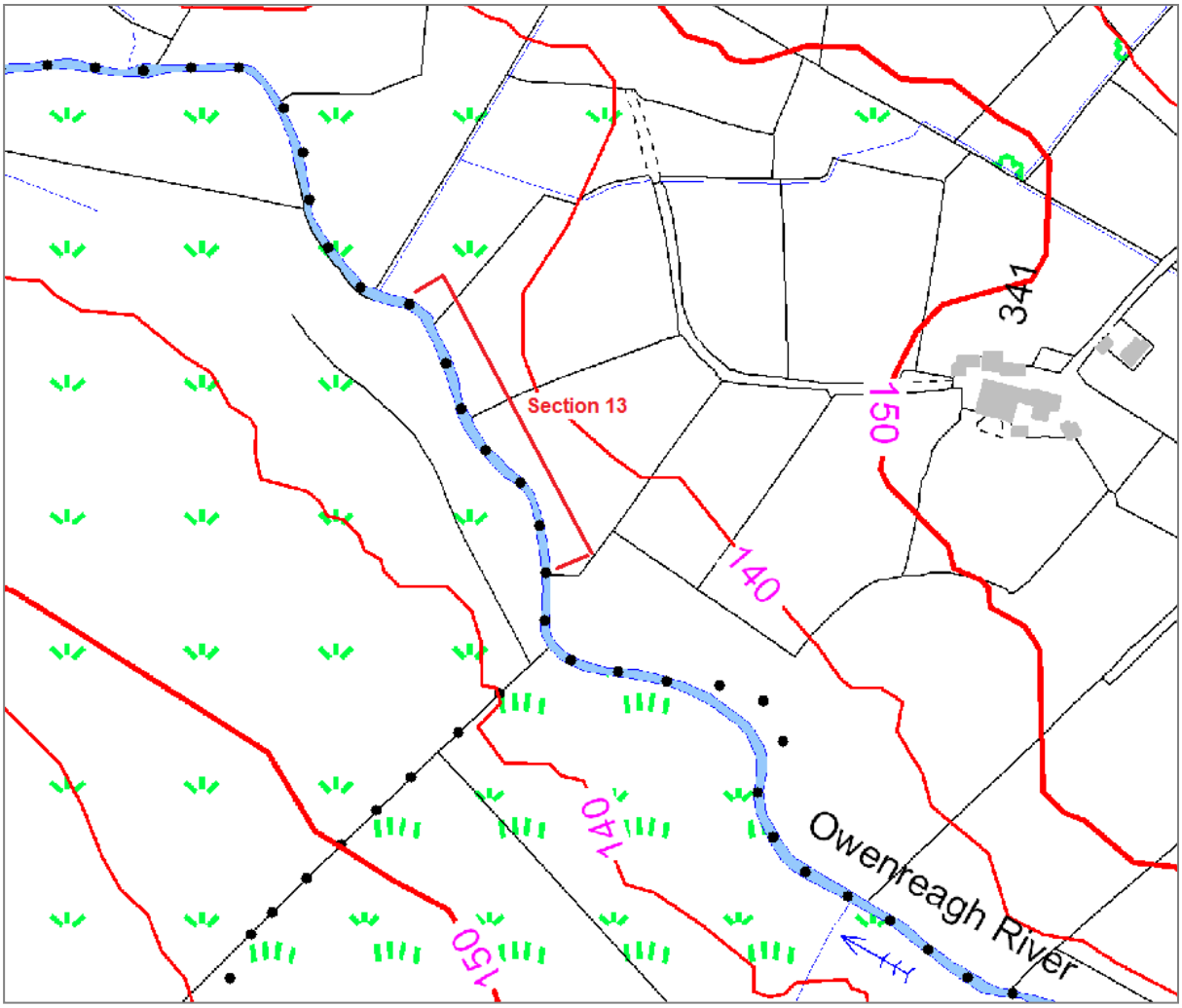
Owenreagh proposed ASSI – Sections #11

Location:	
Start Point GPS: H6056 8176	**Start Point Features**:
End Point GPS: H6049 8176	**End Point Features**:
Approximate distance (m): 55m	
Presence of fine sediments: Small cobble and coarse sand	
Filamentous algae: None recorded	
Total no. live mussels during 2011: 1,100	**Estimated mussels density:** 5.0 mussels/m^2
No. of dead shells 2011: 3	
Issues/Comments: *Ranunculus* present. Hand searching in the *Ranunculus* beds located c.50% of the mussels in this stretch. No fence along right bank. Poor fence along left.	

Owenreagh proposed ASSI – Sections #12

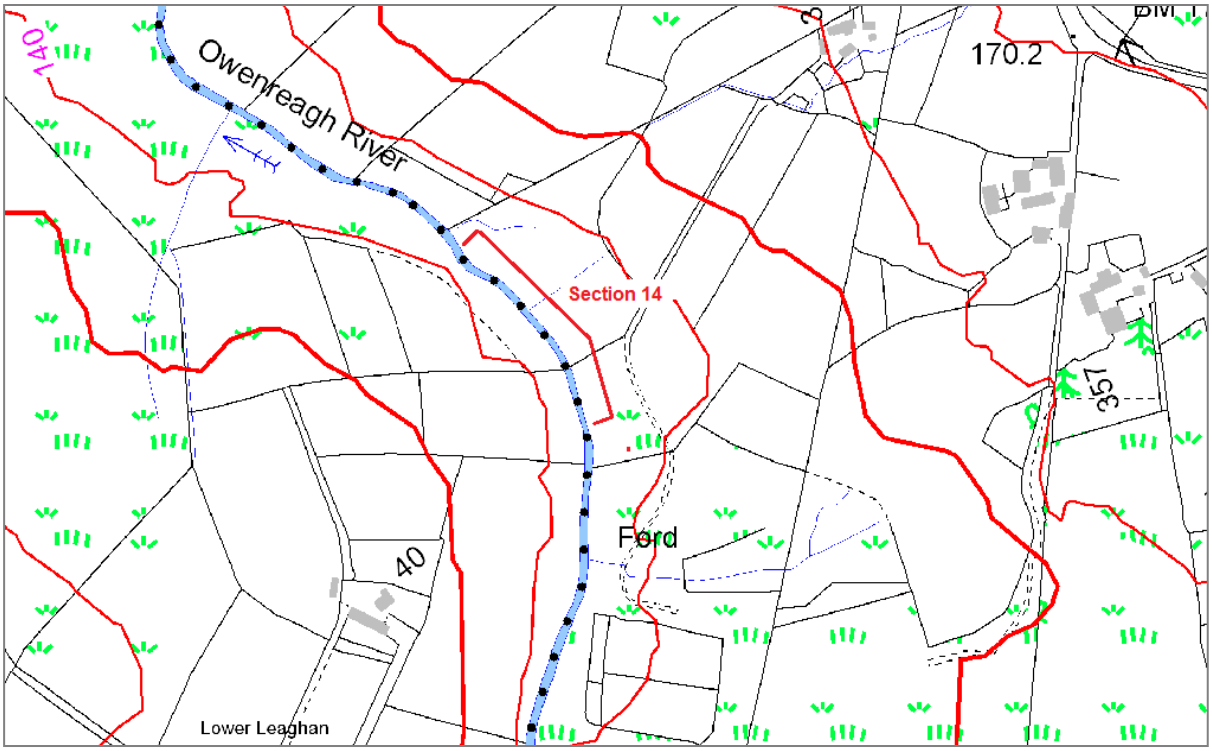
Location:	Downstream of fence crossing channel
Start Point GPS: H6060 8173	**Start Point Features**: Upstream of the 3 Sycamore trees
End Point GPS: H6055 8176	**End Point Features**: Downstream of ash tree
Approximate distance (m): 70m	
Presence of fine sediments: Small cobble and coarse grain sand	
Filamentous algae: None recorded	
Total no. live mussels during 2011: 1,100	**Estimated mussels density:** 4.0 mussels/m^2
No. of dead shells 2011: 12	
Issues/Comments: *Ranunculus* present. > 50% of mussels were found in sand under *Ranucnulus*.	

Owenreagh proposed ASSI – Section #13



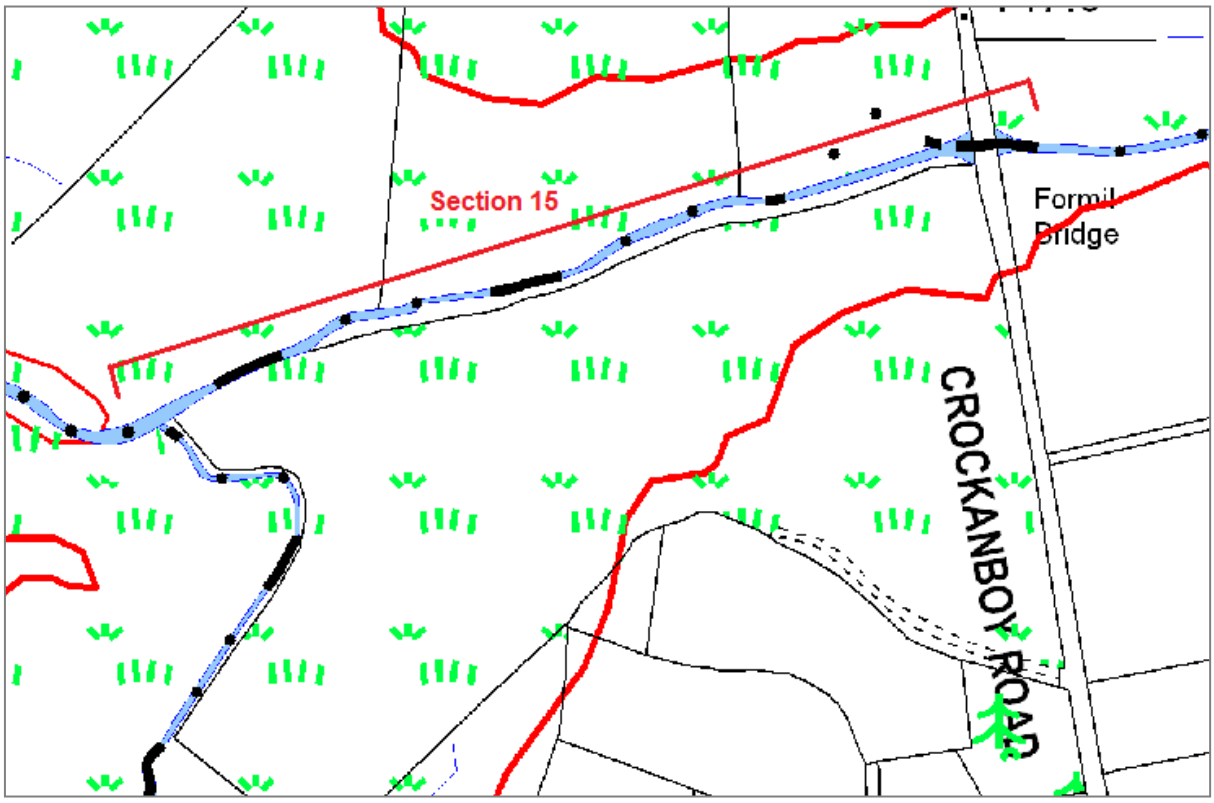
Location:	Downstream of fence crossing channel
Start Point GPS: H6092 8147	**Start Point Features**: Downstream of fence crossing channel and upstream from weed growth
End Point GPS: H6086 8162	**End Point Features**: Bend in the river channel
Approximate distance (m): 150m	
Presence of fine sediments: Small cobble and coarse grain sand	
Filamentous algae: None recorded	
Total no. live mussels during 2011: 353	**Estimated mussels density:** 0.59 mussels/m^2
No. of dead shells 2011: 4	
Issues/Comments: Cattle can access the river from right bank. Two broken shells were found, probably the result of cattle access. No fence along right side. Repaired fence on left.	

Owenreagh proposed ASSI – Section #14



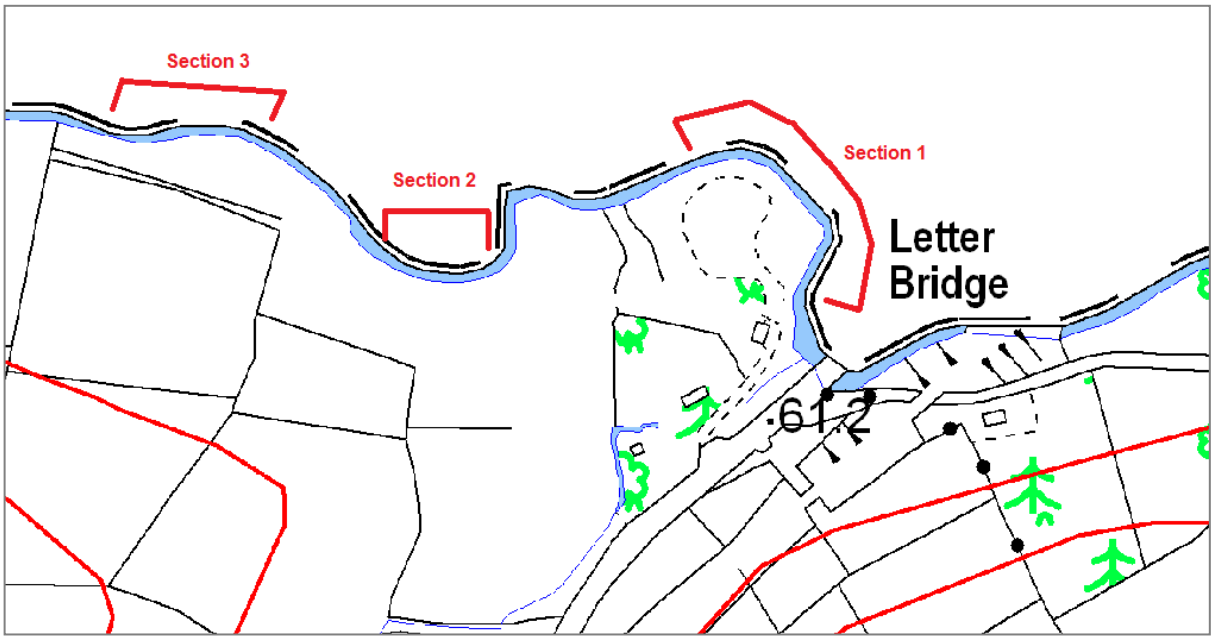
Location:	Downstream of ford	
Start Point GPS: H6132 8109	**Start Point Features**: Site of old foot bridge at end of lane	
End Point GPS: H6123 8121	**End Point Features**: Fence across channel downstream of ash tree	
Approximate distance (m): 140m		
Presence of fine sediments: Largely cobble, boulder and sand		
Filamentous algae: None recorded		
Total no. live mussels during 2011: 233	**Estimated mussels density:** 0.417 mussels/m^2	
No. of dead shells 2011: 7		
Issues/Comments: *Ranunculus* present. No fences upstream of land on right bank. Fence downstream on right bank. No fence downstream of land on left bank. Fence on left bank upstream of lane.		

Owenreagh proposed ASSI – Section #15



Location:	Downstream of Formil Bridge	
Start Point GPS: H6186 8072	**Start Point Features**: Formil Bridge	
End Point GPS: H6150 3806	**End Point Features**: Pine trees downstream of the confluence with the tributary	
Approximate distance (m): 320m		
Presence of fine sediments: Largely boulders, cobble, coarse grain sand and bedrock		
Filamentous algae: None recorded		
Total no. live mussels during 2011: 0	**Estimated mussels density:** 0 mussels/m^2	
No. of dead shells 2011: 0		
Issues/Comments: An elderly lady who lives upstream of Formil Bridge said she remembers mussels there but not any more. This is probable as no mussels were found in Stretch 15. No fence on right bank.		

Waterfoot proposed ASSI – Sections #1-3



Waterfoot non-SAC – Sections #1

Location:	Upstream of Letter Bridge
Start Point GPS: H0848 6517	**Start Point Features**: Letter Bridge
End Point GPS: H0843 6522	**End Point Features**: Drain flowing in on left bank
Approximate distance (m): 60m	
Presence of fine sediments: No plume from bed	
Filamentous algae: <10%	
Total No. Live Mussels Counted 2011: 107	
No. of dead shells 2011: 0	
Issues/Comments: None	

Waterfoot proposed ASSI – Sections #2

Location:	150m upstream of Letter Bridge
Start Point GPS: H0834 6518	**Start Point Features**: 10m downstream of large fallen tree
End Point GPS: H0830 6519	**End Point Features**: Riffle at bend
Approximate distance (m): 60m	
Presence of fine sediments: No plume from bed	
Filamentous algae: <10%	
Total No. Live Mussels Counted 2011: 183	
No. of dead shells 2011: 0	
Issues/Comments: None	

Waterfoot proposed ASSI – Sections #3

Location:	250m upstream of Letter Bridge
Start Point GPS: H0824 6523	**Start Point Features**: Riffle downstream of start of native woodland
End Point GPS: H0819 6523	**End Point Features**: 10m upstream of old fallen tree
Approximate distance (m): 50m	
Presence of fine sediments: No plume from bed	
Filamentous algae: <10%	
Total No. Live Mussels Counted 2011: 116	
No. of dead shells 2011: 0	
Issues/Comments: See sketch map	

ISSN XXXX-XXXX (Print)
ISSN XXXX-XXXX (Online)

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