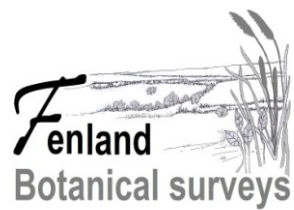


# BOWNESS-ON-SOLWAY NATURE RESERVE

## POND SURVEY



**A report for Freshwater Habitats Trust**



**July 2016**

## 1. Introduction

Bowness-on-Solway Nature Reserve has been identified as a Flagship Pond site by the Freshwater Habitats Trust due to its exceptional importance for freshwater biodiversity. The 7.3 hectare reserve is located close to the Solway estuary and mosses but originates as a gravel quarry from which extraction ceased in the 1970s. It now contains numerous ponds within a matrix of grassland and scrub. The ponds are notable for their population of Mud Snail *Omphiscola glabra*, a seriously declining species.

Nine ponds were surveyed in detail on 22nd June 2016, following a more general search for Mud Snail on 18<sup>th</sup> March. Survey work was undertaken by Martin Hammond and Jonathan Graham.

Seven of the nine ponds were evaluated using the PSYM (**P**redictive **S**ystem for **M**ultimetrics), the standard methodology for assessing the ecological quality of ponds (Environment Agency, 2002)<sup>1</sup>. PSYM uses six 'metrics' (measurements) representing important indicators of ecological quality. The three botanical metrics are:

- diversity of emergent and submerged plant species
- the number of uncommon species
- Trophic Ranking Score (TRS, an indication of nutrient status based on selected plant species)

The three invertebrate family-level metrics are:

- Average Score Per Taxon (ASPT, an estimation of biological water quality based on the sensitivity of different invertebrate families to organic enrichment)
- diversity of dragonfly, damselfly and alderfly families
- diversity of water beetle families

These are based on a timed sample with effort divided equally between each meso-habitat present within the pond (e.g. submerged vegetation, open water, floating-leaved vegetation). PSYM requires identification of invertebrates to family level only but in this survey material was identified to species level wherever possible.

Environmental data obtained for each pond include: surface area, altitude, grid reference, water pH, presence/absence of inflows, substrate composition, degree of shade, accessibility to livestock and cover of emergent vegetation.

The PSYM software compares the observed data with values predicted from a large reference dataset of undegraded ponds. PSYM predicts how a high quality pond with similar attributes *should* score for each metric, and compares the predictions with the survey

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<sup>1</sup> Two of the ponds were considered too seasonal to evaluate using PSYM, which uses reference data from permanent and semi-permanent water bodies.

results. The scores for individual metrics are combined to produce an Index of Biotic Integrity (IBI), which provides an overall indication of the ecological quality of the pond. Ponds can then be categorised as Very Poor, Poor, Medium and Good. PSYM results are provided in Appendix 1 and summarised briefly for the relevant ponds in section 2 below.

## 2. The ponds surveyed

### POND 1 (NY 20646 61759)

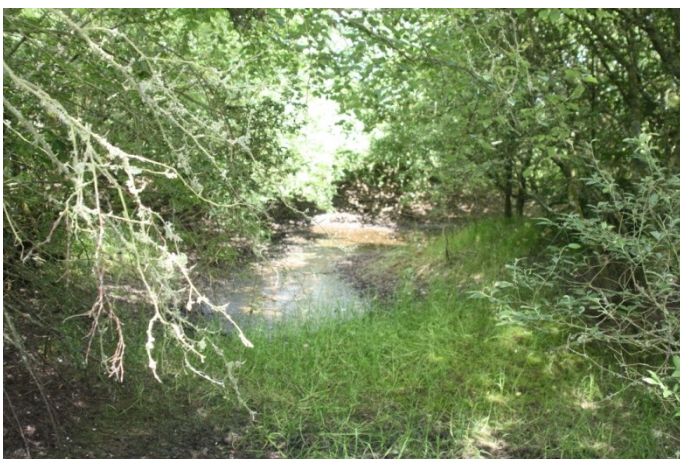


This shallow, horseshoe-shaped pond is the nearest to the entrance of the reserve. It is part-shaded by overhanging willows and has mats of Flote-grass *Glyceria fluitans* as well as small stands of Branched Bur-reed *Sparganium erectum* and Broad-leaved Pondweed *Potamogeton natans*. A water sample produced a pH reading of 5.69 with electrical conductivity of  $110 \mu\text{S}/\text{cm}^{-1}$ .

Eighteen wetland plant species were recorded, including Lesser Spearwort *Ranunculus flammula*. Twenty-one widespread aquatic invertebrate taxa were identified from the PSYM sample. Nine-spined Sticklebacks were numerous and an adult Common Frog was observed.

PSYM assessment produced an Index of Biotic Integrity of 56%, placing Pond 1 within the **Moderate** category for ecological quality. It scored well for diversity of submerged & emergent flora but poorly for representation of uncommon plants and Trophic Ranking Score. Scores for ASPT (biological water quality) and representation of water beetle families were good but no Odonata were found in the invertebrate sample.

### POND 2 (NY 20685 61785)



Pond 2 is shaded amongst Hawthorn and Grey Sallow scrub in the NE corner of the reserve. It is an elongate, shallow, silty water body divided into two connected basins. It was partially dry at the time of the survey and is not suitable for PSYM assessment due to its highly seasonal nature. Nine-spined Sticklebacks are present.

Seventeen wetland plant species and 11 aquatic macro-invertebrate taxa were recorded. A water sample produced a pH reading of 5.83 with electrical conductivity of 130  $\mu\text{S}/\text{cm}^{-1}$ .

Due to its seasonal character, Pond 2 was not suitable for assessment using PSYM.

### **POND 3 (NY 20668 61746)**

This is a large, permanent pond in the north-eastern sector of the reserve. It has an elongate shape with a number of small, shaded embayments and grades into species-rich mire to the east. Dense, swampy vegetation with abundant Water Horsetail *Equisetum fluviatile*, Bog Pondweed *Potamogeton polygonifolius* and Floating Club-rush *Eleogiton fluitans* covers most of the surface. A water sample produced a pH reading of 5.17 with electrical conductivity of 140  $\mu\text{S}/\text{cm}^{-1}$ .

One Nine-spined Stickleback and an adult female Great Crested Newt were caught. Numerous Froglets and Smooth/Palmate Newt tadpoles were found.

Twenty-nine wetland plant species were recorded, making this the most botanically diverse pond surveyed. Species of conservation concern include Marsh Pennywort *Hydrocotyle vulgaris*, Lesser Spearwort, Tormentil *Potentilla erecta* and Marsh Speedwell *Veronica scutellata*. Thirty-two aquatic invertebrate taxa were found, including the Nationally Scarce scavenger water beetles *Hydrochus angustatus* and *Helochares punctatus*. Notably, two Mud Snails *Omphiscola glabra* were found above the water line on Iris leaves in a shaded area on the northern edge of the pond.

PSYM assessment produced an Index of Biotic Integrity of 78%, placing Pond 3 within the top (**Good**) category for ecological quality. It scored well for diversity of submerged & emergent flora and representation of uncommon plants but poorly for Trophic Ranking Score. Scores for ASPT (biological water quality) and representation of water beetle families were good though representation of Odonata & Megaloptera was poor.

### **POND 4 (NY 20627 61664)**



This is a large, relatively deep and steep-sided permanent pond in the western half of the reserve. There is a platform in its NE corner. A wooded island makes access to the southern side of the pond difficult. Emergent vegetation is very limited because most of the pond margin is beneath the tree canopy. Small amounts of Broad-leaved Pondweed and Canadian Pondweed *Elodea*

*canadensis* occur in open water. A water sample produced a pH reading of 4.54 with electrical conductivity of  $160 \mu\text{S}/\text{cm}^{-1}$ .

Eighteen wetland plant species were recorded including Marsh Pennywort. Thirty-five aquatic macro-invertebrate taxa were identified from the PSYM sample including the Nationally Scarce scavenger water beetle *Hydrochus angustatus*. A single Mud Snail was found in the shaded western margin of the pond. Several Smooth/Palmate Newt tadpoles were encountered as well as a moribund adult female Great Crested Newt on the shore.

PSYM assessment produced an Index of Biotic Integrity of 67%, placing Pond 4 within the **Moderate** category for ecological quality. It scored well for diversity of submerged & emergent flora and representation of uncommon plants but poorly for Trophic Ranking Score. It ranked well for diversity of water beetle families and moderately for ASPT but poorly for representation of Odonata.

#### **POND 5 (NY 20637 61709)**

This shallow pond is located to the west of the track (cover photo). It is mostly covered by a raft of Floating Club-rush but contains open pools with Broad-leaved Pondweed, Canadian Pondweed and Flote-grass. A water sample produced a pH reading of 5.34 with electrical conductivity of  $130 \mu\text{S}/\text{cm}^{-1}$ .

Numerous Froglets and Great Crested Newt tadpoles were found along with lesser numbers of Smooth/Palmate Newt tadpoles. Twenty wetland plant species were recorded including Marsh Speedwell and Lesser Spearwort. Thirty-four aquatic macro-invertebrate taxa were identified from the PSYM sample including the Nationally Scarce scavenger water beetle *Hydrochus angustatus*.

PSYM assessment produced an Index of Biotic Integrity of 67%, placing Pond 5 within the **Moderate** category for ecological quality. It scored well for diversity of submerged & emergent flora but poorly for representation of uncommon plants and Trophic Ranking Score. It scored well for biological water quality and diversity of water beetle families, and moderately for representation of Odonata families.

#### **POND 6 (NY 20576 61647)**



This narrow, linear pond is fringed by stands of Soft Rush *Juncus effusus* and Bladder Sedge *Carex vesicaria*. It is not clearly indicated on the reserve map. A water sample produced a pH reading of 5.63 with electrical conductivity of  $150 \mu\text{S}/\text{cm}^{-1}$ .

Sixteen wetland plant species were found including Bladder Sedge and Marsh

Speedwell. Twenty-four aquatic macro-invertebrate taxa were identified from the PSYM sample including the Nationally Scarce scavenger water beetle *Hydrochus angustatus*.

PSYM assessment produced an Index of Biotic Integrity of 56%, placing Pond 6 within the **Moderate** category for ecological quality. It scored moderately for diversity of submerged & emergent flora but poorly for representation of uncommon plants and Trophic Ranking Score. It scored well for ASPT and diversity of water beetle families but poorly for representation of Odonata. Pond 6 may dry out in most summers, so is probably of borderline suitability for assessment using PSYM.

#### **POND 7** (NY 20603 61593)

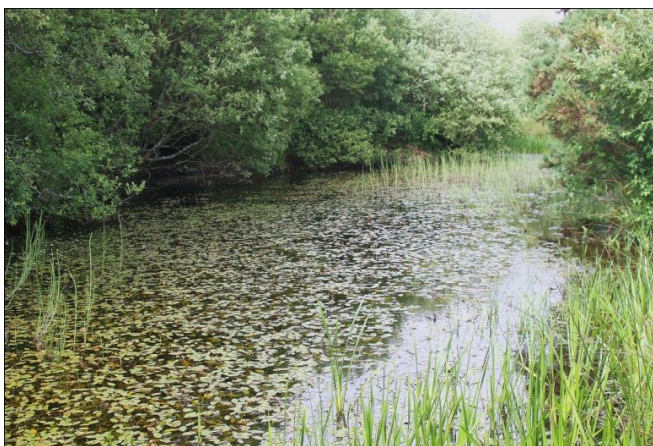


This pond is shown on the reserve map as a large and convoluted water body but parts of it comprise highly seasonal depressions which appear to be connected only when water levels are very high. The area surveyed was a silty mosaic of Flote-grass, Soft Rush, Common Spike-rush *Eleocharis palustris* and Greater Reedmace *Typha latifolia*. As only shallow seasonal pools were present, it was

considered too impermanent to assess using PSYM. A water sample produced a pH reading of 4.96 with electrical conductivity of  $130 \mu\text{S}/\text{cm}^{-1}$ . Smooth/Palmate Newt tadpoles were numerous.

Twenty-three wetland plants species were identified including Marsh Pennywort along with 21 aquatic invertebrate taxa.

#### **POND 8** (NY 20736 61644)



This elongate pond is situated in the south-east sector of the reserve. It has been desilted in recent years and contains stands of Broad-leaved Pondweed. There are also submerged stands of Small Pondweed *Potamogeton berchtoldii*. During the cooler months of the year, there are ill-defined areas of seasonal overspill along the southern margin. A water sample produced a pH

reading of 5.76 with electrical conductivity of  $120 \mu\text{S}/\text{cm}^{-1}$ .

Twenty-seven wetland plants species were identified including Marsh Pennywort, along with 31 aquatic invertebrate taxa. Mud Snails were found in the seasonally-flooded margin of this pond in March but not in the PSYM sample. A few Great Crested Newt tadpoles and an adult female Smooth Newt were caught.

PSYM assessment produced an Index of Biotic Integrity of 83%, placing Pond 8 within the top (**Good**) category for ecological quality. This was the highest scoring pond of the seven evaluated using PSYM. It scored well for diversity of submerged & emergent flora and representation of uncommon plants but poorly for Trophic Ranking Score. Scores for all three invertebrate metrics were good.

#### **POND 9 (NY 20694 61570)**



This steep-sided permanent pond is near the southern edge of the reserve. It contains an island and fringing stands of Flote-grass. A water sample produced a pH reading of 5.96 with electrical conductivity of  $130 \mu\text{S}/\text{cm}^{-1}$ .

Great Crested and Smooth/Palmate Newt tadpoles were numerous.

Twenty-four wetland plants species were identified including Lesser Spearwort. Thirty-two aquatic invertebrate taxa were identified from the PSYM sample including the Nationally Scarce scavenger water beetle *Helochares punctatus*. Mud Snails were found in March but not in June.

PSYM assessment produced an Index of Biotic Integrity of 78%, placing Pond 9 within the top (**Good**) category for ecological quality. It scored well for diversity of submerged & emergent flora and representation of uncommon plants but poorly for Trophic Ranking Score. Scores for ASPT (biological water quality) and representation of water beetle families were good though representation of Odonata & Megaloptera was moderate.

## 3. Results

### 3.1 Water chemistry

Water samples from each pond were tested for pH and electrical conductivity (a measure of solute content) the day after collection using a freshly-calibrated laboratory standard meter. The results were strikingly consistent: water was moderately acidic (pH 4.51 to 5.96, mean = 5.43) and of low conductivity (110 to 160  $\mu\text{S}/\text{cm}^{-1}$ , mean = 134). These readings are unusual for lowland ponds in agricultural landscapes, where buffering from clay or silt soils typically produces a pH around neutral (pH 7) and enrichment of pond catchments tends to elevate conductivity readings, often to levels  $>400 \mu\text{S}/\text{cm}^{-1}$ . Nonetheless, these readings are above what would be expected for lowland bogs and upland moorland ponds. They indicate conditions which are probably close to 'natural' for lowland ponds on base-poor gravel soils in semi-natural habitats.

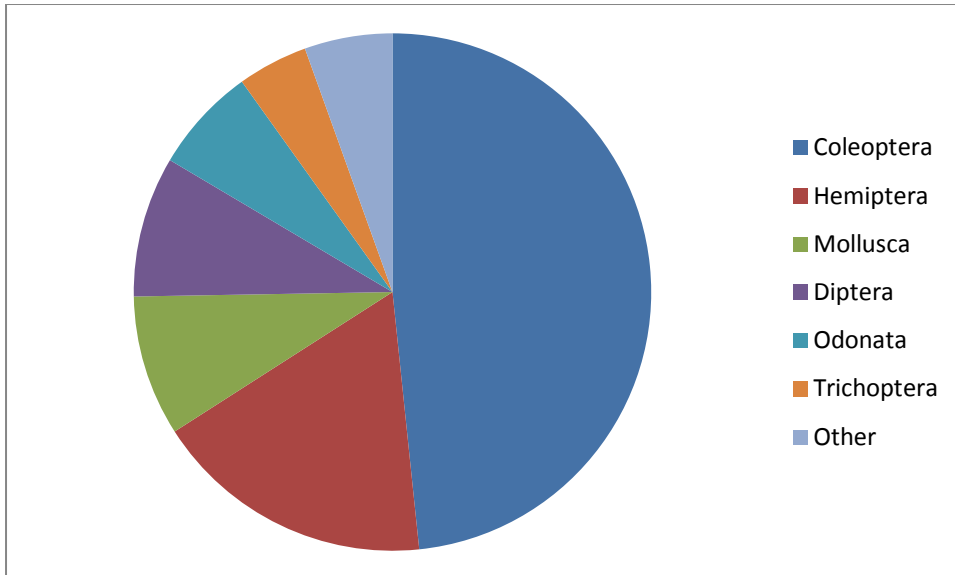
Relatively low water pH will limit colonisation by fish and therefore encourage amphibian populations. It is worth noting that the mean pH reading for the five ponds from which Great Crested Newt was recorded was 5.35, which illustrates the tolerance of this species. Mud Snail favours relatively calcium-poor waters because this reduces competition from other water snails. Maintenance of the natural hydrology of the reserve is therefore important for key species.

### 3.2 Invertebrates

A total of 91 aquatic macro-invertebrate taxa were recorded (Appendix 2) and raw data have been provided in spreadsheet format. Three species of conservation concern were identified (Mud Snail and the scavenger water beetles *Hydrochus angustatus* and *Helochares punctatus*). There were also several locally-distributed species such as the diving beetles *Rhantus exsoletus* and *Ilybius guttiger* and the scavenger water beetle *Enochrus ochropterus*. There is not a well-developed bog-pool fauna: no species closely associated with *Sphagnum* mires were recorded. However, there are a few acid-water specialists such as the Moorland Backswimmer *Notonecta obliqua* and the lesser water-boatman *Hesperocorixa castanea*.

As is typical for shallow lowland ponds, water beetles (Coleoptera) made up nearly half the taxa recorded (48 %) (Figure 1).





**Figure 1: taxonomic composition of the aquatic macro-invertebrate fauna in nine ponds at Bowness-on-Solway Nature Reserve sampled by hand-netting**

### 3.3 Vertebrates

The ponds support large breeding populations of amphibians, though these were recorded only casually. Common Frog adults or tadpoles were found in three ponds and Smooth/Palmate Newt tadpoles in five. An adult Smooth Newt was netted in Pond 8. There is evidently an important population of Great Crested Newt, with tadpoles found in four ponds including large numbers in Ponds 5 and 9. Individual adults of this species were observed in Ponds 3 and 4. Nine-spined Sticklebacks were observed in Ponds 1 to 3.

### 3.4 Wetland plants

A total of 51 wetland plant species were recorded (Appendix 3), i.e. species listed on the PSYM/NPS recording form plus wetland bryophytes. Several widespread but declining wetlands herbs are present (Bladder Sedge, Marsh Pennywort, Lesser Spearwort, Marsh Speedwell) amongst a wide suite of species characteristic of low-nutrient, rather base-poor waters (e.g. White Sedge *Carex canescens*, Common Sedge *C. nigra*, Floating Club-rush, Water Purslane *Lythrum portula*, Small Pondweed, Bog Pondweed, Round-leaved Water-crowfoot *Ranunculus omiophyllus* and the bog-mosses *Sphagnum denticulatum*, *S. fallax* and *S. squarrosum*). There are also a few species of more base-rich, fen-type habitats such as Purple Small-reed *Calamagrostis canescens* (recorded from three ponds) and Northern Marsh Orchid *Dactylorhiza purpurella* (found in one).

Thus, despite the lack of national rarities, Bowness-on-Solway Nature Reserve supports an impressive wetland flora indicative of clean-water habitats, especially for a small lowland site. The flora suggests the reserve has good hydrological integrity and there is little indication that it is impacted upon by surrounding land use.

In addition to individual plant species, the reserve is notable for a plant community characterised by floating or semi-floating mats of Floating Club-rush with Bog Pondweed, Water Horsetail and a variety of poor-fen herbs. This is well-developed in Ponds 3 & 5 and should be considered a special feature of the site. Nothing really comparable has been described in the National Vegetation Classification (e.g. Rodwell, 1992 & 1995), though it clearly has some association with communities of oligotrophic and acidic still waters such as the A24 *Juncus bulbosus* community. It may have developed its peculiar character in the absence of more bulky plants such as Bottle Sedge *Carex rostrata*, Bogbean *Menyanthes trifoliata* or Marsh Cinquefoil *Comarum palustre* which form the architecture of the S27 *C. rostrata* – *C. palustre* tall-herb fen. Such swampy or raft-forming vegetation is invariably rich in invertebrates, providing habitat for terrestrial species which live on the surface vegetation such as spiders and rove beetles as well as fully aquatic taxa which occupy the submerged zone. It is possible that mosses such as Heart-leaved Spear-moss *Calliergon cordifolium* or Sphagna will colonise the surface of these ponds more extensively in future.

Only one alien plant, Canadian Pondweed *Elodea canadensis*, was found: although often regarded as invasive in the past, this plant has almost become an honorary native and in fact avoids the eutrophicated habitats favoured by more vigorous alien water plants. Canadian Pondweed does not present a management problem on the reserve. However, constant vigilance is required to prevent any future colonisation by New Zealand Pygmyweed *Crassula helmsii*, which would be very harmful to key features such as floating fen and fluctuating water margins.

### **3.5 PSYM assessment**

Seven of the ponds were assessed using PSYM, though Pond 6 was of borderline suitability. Ponds 2 and 7 were considered too strongly seasonal. Three ponds (3, 8 & 9) were assessed as being of Good ecological quality, the other four being of Moderate quality.

Six of the seven ponds supported a diversity of submerged and emergent flora close to that predicted for high quality ponds with similar attributes. Ponds 3 and 8 were more species-rich than the model predicted. Representation of uncommon wetland plants varied from poor to good, smaller water bodies such as Pond 1 and Pond 6 having low scores.

Trophic Ranking Score was poor or very poor for all seven ponds. This means that the average score for trophic indicator plants was significantly higher than predicted. Usually this would suggest excessive nutrient enrichment but this metric may be misleading for the Bowness-on-Solway ponds. The TRS metric is based on a limited number of plants and does not include species such as White Sedge and Floating Club-rush which are indicative of low-nutrient conditions. It also scores vascular plants individually but only uses a collective score for Sphagna: if the two *Sphagnum* species in Ponds 3 and 8 were scored individually, this would lower the Trophic Ranking Score for those ponds. It is also likely that the relatively low water pH of these ponds meant that the software compared them to reference data for

oligotrophic bog-pools. The TRS scores are in fact consistently low for lowland ponds and are not cause for concern.

Diversity of water beetle families was consistently good and biological water quality (ASPT) was mostly good (it was moderate in Pond 6). Damselflies, dragonflies and alderflies were not found at all in Pond 1, were poorly represented in three ponds (3, 4 and 6) and were moderately represented in Ponds 5 and 9. Only Pond 8 supported family-level diversity close to that predicted. Poorer than expected results for Odonata are probably due to a range of factors including shade (Pond 1); impermanence (Pond 6 and possibly Pond 1); poor aquatic and marginal vegetation structure (Pond 4); and lack of open water in the case of Pond 3.

### 3.6 Priority Pond status

Priority Ponds are defined as the best ca. 20% of ponds in England and Wales based on a range of criteria. These were originally developed for the UK Biodiversity Action Plan but Priority Ponds are recognised as a Habitat of Principal Importance for conservation under Section 41 of the Natural Environment & Rural Communities Act. Five of the nine ponds surveyed meet at least one criterion for Priority Pond status (Table 1).

Pond	3	4	5	8	9
PSYM Good ecological quality	✓			✓	✓
UKBAP species/Species of Principal Importance	Mud Snail, Great Crested Newt	Mud Snail, Great Crested Newt	Great Crested Newt	Mud Snail, Great Crested Newt	Mud Snail, Great Crested Newt
3 or more Nationally Scarce invertebrate species	<i>Hydrochus angustatus</i> , <i>Helochares punctatus</i> , Mud Snail				

**Table 1: Application of Priority Pond criteria**

## 4. Species of conservation concern

### 4.1 Invertebrates

#### **Mud Snail** *Omhiscola glabra* (Lymnaeidae)

GB status: Nationally Scarce; Species of Principal Importance

Global status: Near Threatened (Prié *et al.*, 2011)



Mud Snail is a pond snail closely associated with nutrient-poor pool systems and pond margins on agriculturally-unimproved land. This species favours seasonal water bodies or draw-down zones around more permanent ponds. It appears to be poorly dispersive and most sites are on remnants of semi-natural heaths and commons; it is likely that the gravel workings at Bowness-on-Solway NR have inherited a population previously present on surrounding grazing marsh or fen. Mud Snail has declined massively, with post-1999 records from only 47 hectads in Great Britain (Seddon *et al.*, 2014). The global population was recently estimated to have declined by 20-25% over 15 years with a 25-49% decline in Great Britain during the period 1985-2010 (Prié *et al.*, 2011). It is scarce and declining in most parts of its limited global range (Mud Snail is restricted to Western Europe) and has become extinct in Ireland and Poland.

During the June survey, two Mud Snails were found on emergent vegetation at the edge of Pond 3 and one was found at the margin of Pond 4. In April, larger numbers were present in seasonal habitats in Ponds 8 & 9.

#### **Hydrochus angustatus**, a scavenger water beetle (Hydrochidae)

GB status: Nationally Scarce

This small water beetle inhabits richly-vegetated water margins on fens and heaths in southern and western Britain. It formerly occurred at one site in south-west Scotland but appears to be extinct there (Foster *et al.*, 2014), so a cluster of sites on the Cumbrian side of the Solway represent its northernmost stronghold. There is a strong population at Bowness-on-Solway NR, with records of numerous individuals from five ponds in June 2016.

#### **Helochares punctatus**, a scavenger water beetle (Hydrophilidae)

GB status: Nationally Scarce

Although listed as Nationally Scarce by Foster (2010), *H. punctatus* is a localised rather than rare beetle, mostly associated with acidic bog-pools at low to moderate elevations but sometimes occurring in base-rich ponds. It was collected from Ponds 3 and 9 during this survey.

## 4.2 Wetland plants

### ***Carex vesicaria*, Bladder Sedge**

England status: Vulnerable

This tall sedge occurs in various water-margin habitats, usually in waters of intermediate fertility. It underwent a 34% decline in distribution in England during the second half of the 20<sup>th</sup> century (Stroh *et al.*, 2014). On the reserve, substantial clumps can be seen in Pond 6.

### ***Hydrocotyle vulgaris*, Marsh Pennywort**

English status: Near Threatened

A humble plant of short vegetation in water margins and wet fens which, like many species of less fertile wetlands, is undergoing a long-term decline in distribution in England. It was found in Ponds 3, 4, 7 & 8.

### ***Potentilla erecta*, Tormentil**

English status: Near Threatened

A common upland flower which is restricted to a diminishing number of unimproved grasslands, heaths and fens in the lowlands. Tormentil was present in the mire in Pond 3.

### ***Ranunculus flammula*, Lesser Spearwort**

English status: Vulnerable

Although still widespread and locally frequent, Lesser Spearwort underwent a 32% decline in distribution in England during the latter half of the last century (Stroh *et al.*, 2014). It was recorded from Ponds 1, 5, 8 & 9.

### ***Veronica scutellata*, Marsh Speedwell**

English status: Near Threatened

A moderately declining species of water-margins on poorer soils, Marsh Speedwell was found in Ponds 3, 5 & 6.

## 5. Implications for conservation management

It is perhaps surprising that the reserve does not support a greater diversity of aquatic plants because water chemistry readings are favourable for a wide range of species associated with low-nutrient, moderately acidic conditions. It may be that opportunities for colonisation are limited because agents of dispersal such as waterfowl are not attracted to ponds enclosed by woodland. However, it is likely that additional species will arrive over time given the proximity of donor habitats such as the Solway Mosses.

Invertebrate diversity reflects vegetation structure, and ponds with extensive and structurally-complex (multi-layered) emergent vegetation will usually support richer and more diverse communities of wetland invertebrates. Ongoing management to reduce shading of shallow water margins will be beneficial and Pond 4 is an obvious candidate for more concerted reduction of shoreline tree cover; this need not be drastic but removing overhanging trees from just a small proportion of the shore would encourage the development of emergent vegetation.

Ponds 3 and 5 support very extensive emergent vegetation including semi-floating carpets of species such as Floating Club-rush, Bog Pondweed and Water Horsetail. This habitat supports very rich invertebrate communities and such 'late successional' ponds are often much more biodiverse than those with a higher proportion of open water. It is likely that over time, floating mats of vegetation will become colonised by more base-tolerant bog-mosses such as *Sphagnum squarrosum*, resulting in the development of 'poor-fen' habitat. Provided sufficient open-water is maintained on the reserve as a whole for species such as Great Crested Newt, this should be welcomed: lowland poor-fen is much rarer than open water and very few sites provide suitable conditions for its development. Similar habitat was probably more extensive in the past on the periphery of raised mires but transitional 'lagg' fens have often been lost or damaged by agricultural improvement, drainage or eutrophication. In these ponds, management should be limited to removal of any encroaching scrub within the pond basin, protection of the hydrological integrity of the reserve and occasional monitoring.

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## APPENDIX 1: PSYM DATA

	Bowness	Bowness	Bowness	Bowness	Bowness	Bowness	Bowness
Pond Code	Pond 1	Pond 3	Pond 4	Pond 5	Pond 6	Pond 8	Pond 9
Date	23-Jun-16	23-Jun-16	23-Jun-16	23-Jun-16	23-Jun-16	22-Jun-16	22-Jun-16
Grid ref	NZ 206 617	NZ 206 617	NZ 206 616	NZ 206 617	NZ 205 616	NZ 207 616	NZ 206 615
Plant metrics							
No. of submerged + marginal plant species (not including floating leaved)	14	24	14	15	12	20	16
Number of uncommon plant species	1	5	4	1	1	3	4
TRS	8.5857143	6.65	7.825	7.4285714	6.7	7.48	6.9166667
Invertebrate metrics							
ASPT	4.6666667	4.4285714	4.4666667	5.2142857	5	4.6666667	5.0714286
Odonata + Megaloptera	0	1	1	2	1	3	2
Coleoptera	4	3	4	4	4	4	4
Environmental variables							
Altitude	4	4	6	4	6	4	9
Shade (%)	50	10	10	10	10	10	10
Inflow (0/1)	0	0	0	0	0	0	0
Grazing (%)	0	0	0	0	0	0	0
Water pH	5.71	5.23	4.63	5.34	5.63	5.07	5.96
Emergent plant cover (%)	40	80	3	65	40	20	15
Base: silt/clay (1-3)	3	3	2	3	3	3	3
Base: sand/gravel (1-3)	1	1	2	1	1	1	1
Base: peat (1-3)	1	1	1	1	1	1	1
Base: rock (1-3)	1	1	1	1	1	1	1
Area (m <sup>2</sup> )	260	1160	1457	1078	30	1210	313
RESULTS							
Submerged + marginal plants							
Predicted	18.3	17.7	17.0	17.7	20.5	17.6	18.6
Actual	14	24	14	15	12	20	16
EQI	0.76	1.36	0.82	0.85	0.59	1.13	0.86
IBI	3	3	3	3	2	3	3
Uncommon plants							
Predicted	3.9	4.0	3.8	4.0	4.6	4.0	4.2
Actual	1	5	4	1	1	3	4



EQI	0.26	1.26	1.07	0.25	0.22	0.76	0.96
IBI	1	3	3	1	0	3	3
TRS							
Predicted	6.25	5.60	5.52	5.61	5.61	5.59	5.66
Actual	8.59	6.65	7.83	7.43	6.70	7.48	6.92
EQI	1.37	1.19	1.42	1.33	1.19	1.34	1.22
IBI	0	1	0	0	1	0	0
ASPT							
Predicted	5.11	5.17	5.54	5.18	5.13	5.31	5.16
Actual	4.67	4.43	4.47	5.21	5.00	4.67	5.07
EQI	0.91	0.86	0.81	1.01	0.97	0.88	0.98
IBI	3	3	2	3	3	3	3
OM families							
Predicted	3.34	3.45	3.78	3.46	3.26	3.67	3.33
Actual	0	1	1	2	1	3	2
EQI	0.00	0.29	0.26	0.58	0.31	0.82	0.60
IBI	0	1	1	2	1	3	2
Coleoptera families							
Predicted	3.80	3.81	3.57	3.81	3.84	3.82	3.80
Actual	4	3	4	4	4	4	4
EQI	1.05	0.79	1.12	1.05	1.04	1.05	1.05
IBI	3	3	3	3	3	3	3
Predicted							
<b>Sum of Individual Metrics</b>	10	14	12	12	10	15	14
<b>Index of Biotic Integrity (%)</b>	<b>56%</b>	<b>78%</b>	<b>67%</b>	<b>67%</b>	<b>56%</b>	<b>83%</b>	<b>78%</b>
<b>PSYM quality category (IBI &gt;75%=Good, 51-75%= Moderate, 25-50%=Poor, &lt;25%=V Poor)</b>	<b>Moderate</b>	<b>Good</b>	<b>Moderate</b>	<b>Moderate</b>	<b>Moderate</b>	<b>Good</b>	<b>Good</b>
<b>Priority Pond? (Good ecological quality)</b>	<b>NO</b>	<b>YES</b>	<b>NO</b>	<b>NO</b>	<b>NO</b>	<b>YES</b>	<b>YES</b>

## APPENDIX 2:

### AQUATIC MACRO-INVERTEBRATE TAXA RECORDED FROM BOWNESS-ON-SOLWAY NATURE RESERVE IN 2016

SPECIES	ENGLISH NAME	FAMILY	ORDER
<i>Crangonyx pseudogracilis</i>	an amphipod shrimp	Crangonyctidae	Amphipoda
<i>Musculium lacustre</i>	Capped Orb-mussel	Sphaeriidae	Bivalvia
<i>Pisidium</i> sp.	a pea-mussel	Sphaeriidae	Bivalvia
<i>Donacia versicolorea</i>	a reed-beetle	Chrysomelidae	Coleoptera
<i>Acilius sulcatus</i>	a diving beetle	Dytiscidae	Coleoptera
<i>Agabus bipustulatus</i>	a diving beetle	Dytiscidae	Coleoptera
<i>Agabus sturmi</i>	a diving beetle	Dytiscidae	Coleoptera
<i>Colymbetes fuscus</i>	a diving beetle	Dytiscidae	Coleoptera
<i>Dytiscus marginalis</i>	Great Diving Beetle	Dytiscidae	Coleoptera
<i>Hydroporus angustatus</i>	a diving beetle	Dytiscidae	Coleoptera
<i>Hydroporus erythrocephalus</i>	a diving beetle	Dytiscidae	Coleoptera
<i>Hydroporus gyllenhali</i>	a diving beetle	Dytiscidae	Coleoptera
<i>Hydroporus incognitus</i>	a diving beetle	Dytiscidae	Coleoptera
<i>Hydroporus memnonius castaneus</i>	a diving beetle	Dytiscidae	Coleoptera
<i>Hydroporus palustris</i>	a diving beetle	Dytiscidae	Coleoptera
<i>Hydroporus planus</i>	a diving beetle	Dytiscidae	Coleoptera
<i>Hydroporus pubescens</i>	a diving beetle	Dytiscidae	Coleoptera
<i>Hydroporus tessellatus</i>	a diving beetle	Dytiscidae	Coleoptera
<i>Hydroporus umbrosus</i>	a diving beetle	Dytiscidae	Coleoptera
<i>Hygrotus impressopunctatus</i>	a diving beetle	Dytiscidae	Coleoptera
<i>Hygrotus inaequalis</i>	a diving beetle	Dytiscidae	Coleoptera
<i>Hyphydrus ovatus</i>	a diving beetle	Dytiscidae	Coleoptera
<i>Ilybius ater</i>	a diving beetle	Dytiscidae	Coleoptera
<i>Ilybius fuliginosus</i>	a diving beetle	Dytiscidae	Coleoptera
<i>Ilybius guttiger</i>	a diving beetle	Dytiscidae	Coleoptera
<i>Ilybius montanus</i>	a diving beetle	Dytiscidae	Coleoptera
<i>Laccophilus minutus</i>	a diving beetle	Dytiscidae	Coleoptera
<i>Rhantus exoletus</i>	a diving beetle	Dytiscidae	Coleoptera
<i>Gyrinus substriatus</i>	Common Whirligig beetle	Gyrinidae	Coleoptera
<i>Haliplus ruficollis</i>	an algivorous water beetle	Haliplidae	Coleoptera
<i>Helophorus aequalis</i>	a scavenger water beetle	Helophoridae	Coleoptera
<i>Helophorus brevipalpis</i>	a scavenger water beetle	Helophoridae	Coleoptera
<i>Helophorus flavipes</i>	a scavenger water beetle	Helophoridae	Coleoptera
<i>Helophorus grandis</i>	a scavenger water beetle	Helophoridae	Coleoptera
<i>Helophorus griseus/minutus</i>	a scavenger water beetle	Helophoridae	Coleoptera
<i>Hydraena riparia</i>	a moss beetle	Hydraenidae	Coleoptera
<i>Hydrochus angustatus</i>	a scavenger water beetle	Hydrochidae	Coleoptera
<i>Anacaena globulus</i>	a scavenger water beetle	Hydrophilidae	Coleoptera

<i>Anacaena lutescens</i>	a scavenger water beetle	Hydrophilidae	Coleoptera
<i>Coelostoma orbiculare</i>	a scavenger water beetle	Hydrophilidae	Coleoptera
<i>Enochrus coarctatus</i>	a scavenger water beetle	Hydrophilidae	Coleoptera
<i>Enochrus ochropterus</i>	a scavenger water beetle	Hydrophilidae	Coleoptera
<i>Helochares punctatus</i>	a scavenger water beetle	Hydrophilidae	Coleoptera
<i>Hydrobius fuscipes</i>	a scavenger water beetle	Hydrophilidae	Coleoptera
<i>Hydrobius subrotundus</i>	a scavenger water beetle	Hydrophilidae	Coleoptera
<i>Noterus clavicornis</i>	a burrowing water beetle	Noteridae	Coleoptera
<i>Contacyphon</i> sp. larva	a marsh beetle	Scirtidae	Coleoptera
Chaoboridae	phantom midge larvae	Chaoboridae	Diptera
indet larvae	phantom midge larvae	Chaoboridae	Diptera
Chironomidae (other)	non-biting midge larvae	Chironomidae	Diptera
<i>Chironomus</i> sp.	non-biting midge larvae	Chironomidae	Diptera
Culicidae	mosquito larvae	Culicidae	Diptera
Dixidae	meniscus midge larvae	Dixidae	Diptera
<i>Eristalinus</i> sp. larva	a rat-tailed maggot	Syrphidae	Diptera
<i>Cloeon dipterum</i>	Pond Olive	Baetidae	Ephemeroptera
<i>Galba truncatula</i>	Dwarf Pond Snail	Lymnaeidae	Gastropoda
<i>Lymnaea stagnalis</i>	Greater Pond Snail	Lymnaeidae	Gastropoda
<i>Omphiscola glabra</i>	Mud Snail	Lymnaeidae	Gastropoda
<i>Radix balthica</i>	Wandering Snail	Lymnaeidae	Gastropoda
<i>Gyraulus albus</i>	White Ramshorn snail	Planorbidae	Gastropoda
<i>Planorbis planorbis</i>	Margined Ramshorn snail	Planorbidae	Gastropoda
<i>Callicorixa praeusta</i>	a lesser water-boatman	Corixidae	Hemiptera
<i>Corixa punctata</i>	a lesser water-boatman	Corixidae	Hemiptera
<i>Hesperocorix castanea</i>	a lesser water-boatman	Corixidae	Hemiptera
<i>Hesperocorix sahlbergi</i>	a lesser water-boatman	Corixidae	Hemiptera
<i>Hesperocorix castanea</i>	lesser water-boatmen	Corixidae	Hemiptera
<i>Hesperocorix linnaei</i>	lesser water-boatmen	Corixidae	Hemiptera
<i>Hesperocorix sahlbergi</i>	a lesser water-boatman	Corixidae	Hemiptera
<i>Sigara distincta</i>	a lesser water-boatman	Corixidae	Hemiptera
<i>Sigara semistriata</i>	lesser water-boatmen	Corixidae	Hemiptera
<i>Gerris lacustris</i>	Common Pond-skater	Gerridae	Hemiptera
<i>Hydrometra stagnorum</i>	Water-measurer	Hydrometridae	Hemiptera
<i>Nepa cinerea</i>	Water Scorpion	Nepidae	Hemiptera
<i>Notonecta glauca</i>	Common Backswimmer	Notonectidae	Hemiptera
<i>Notonecta obliqua</i>	Moorland Backswimmer	Notonectidae	Hemiptera
<i>Plea minutissima</i>	Pygmy Backswimmer	Pleidae	Hemiptera
<i>Microvelia reticulata</i>	a lesser water-cricket	Veliidae	Hemiptera
<i>Theromyzon tessulatum</i>	Duck Leech	Glosiphoniidae	Hirudinea
<i>Sialis lutaria</i>	Common Alderfly	Sialidae	Megaloptera
<i>Aeshna</i> sp.	a hawk dragonfly larva	Aeshnidae	Odonata
<i>Coenagrion puella</i>	Azure Damselfly	Coenagrionidae	Odonata

<i>Ischnura elegans</i>	Blue-tailed Damselfly larvae	Coenagrionidae	Odonata
<i>Pyrrhosoma nymphula</i>	Large Red Damselfly larvae	Coenagrionidae	Odonata
<i>Lestes sponsa</i>	Emerald Damselfly larvae	Lestidae	Odonata
<i>Libellula quadrimaculata</i>	Four-spotted Chaser	Libellulidae	Odonata
Oligochaeta	worms	Oligochaeta	Oligochaeta
<i>Glyptotaelius pellucidus</i>	a caddis fly	Limnephilidae	Trichoptera
<i>Limnephilus</i> (other)	a caddis fly	Limnephilidae	Trichoptera
<i>Limnephilus lunatus</i>	a caddis fly	Limnephilidae	Trichoptera
<i>Limnephilus vittatus</i>	a caddis fly	Limnephilidae	Trichoptera
Turbellaria sp.	a flatworm	Planariidae	Turbellaria

### APPENDIX 3:

#### WETLAND PLANTS RECORDED FROM BOWNESS-ON-SOLWAY NATURE RESERVE IN 2016

SPECIES	ENGLISH NAME
<i>Agrostis canina</i>	Velvet Bent
<i>Agrostis stolonifera</i>	Creeping Bent
<i>Alisma plantago-aquatica</i>	Common Water-plantain
<i>Calamagrostis canescens</i>	Purple Small-reed
<i>Calliergon cordifolium</i>	Heart-leaved Spear-moss
<i>Calliergonella cuspidata</i>	Pointed Spear-moss
<i>Callitriche stagnalis</i>	Water-starwort
<i>Cardamine pratensis</i>	Lady's Smock
<i>Carex canescens</i>	White Sedge
<i>Carex nigra</i>	Common Sedge
<i>Carex vesicaria</i>	Bladder Sedge
<i>Cirsium palustre</i>	Marsh Thistle
<i>Dactylorhiza purpurella</i>	Northern Marsh Orchid
<i>Deschampsia cespitosa</i>	Tufted Hair-grass
<i>Eleocharis palustris</i>	Common Spike-rush
<i>Eleogiton fluitans</i>	Floating Club-rush
<i>Elodea canadensis</i>	Canadian Pondweed
<i>Epilobium palustre</i>	Marsh Willowherb
<i>Epilobium tetragonum</i>	Square-stalked Willowherb
<i>Equisetum fluviatile</i>	Water Horsetail
<i>Galium palustre ssp. palustre</i>	Common Marsh Bedstraw
<i>Glyceria fluitans</i>	Flote-grass
<i>Hydrocotyle vulgaris</i>	Marsh Pennywort
<i>Iris pseudacorus</i>	Yellow Flag Iris
<i>Juncus acutiflorus</i>	Sharp-flowered Rush
<i>Juncus bufonius</i>	Toad Rush
<i>Juncus conglomeratus</i>	Compact Rush
<i>Juncus effusus</i>	Soft Rush
<i>Lemna minor</i>	Common Duckweed
<i>Leptodictyum riparium</i>	Kneiff's Feather-moss
<i>Lotus pedunculatus</i>	Greater Birdsfoot Trefoil
<i>Lythrum portula</i>	Water Purslane
<i>Mentha aquatica</i>	Water Mint
<i>Myosotis laxa ssp. caespitosa</i>	Tufted Forget-me-not
<i>Myosotis scorpioides</i>	Water Forget-me-not
<i>Persicaria amphibia</i>	Amphibious Bistort
<i>Polytrichum commune var. commune</i>	Common Haircap Moss
<i>Potamogeton berchtoldii</i>	Small Pondweed

<i>Potamogeton natans</i>	Broad-leaved Pondweed
<i>Potamogeton polygonifolius</i>	Bog Pondweed
<i>Potentilla erecta</i>	Tormentil
<i>Ranunculus flammula</i>	Lesser Spearwort
<i>Ranunculus omiophyllus</i>	Round-leaved Water-crowfoot
<i>Solanum dulcamara</i>	Woody Nightshade
<i>Sparganium erectum</i>	Branched Bur-reed
<i>Sphagnum denticulatum</i>	Cow's-horn Bog-moss
<i>Sphagnum fallax</i>	Flat-topped Bog-moss
<i>Sphagnum squarrosum</i>	Spiky Bog-moss
<i>Stellaria alsine</i>	Bog Stitchwort
<i>Typha latifolia</i>	Greater Reedmace
<i>Veronica scutellata</i>	Marsh Speedwell