Assessment of grassland fungi at Lisvane and Llanishen reservoirs

Dwr Cymru Welsh Water

APEM Ref. P000001231

January 2017

Peter Sturgess

Client:	Dwr Cymru Welsh Water
Address:	Pentwyn Road, Nelson, Treharris, Mid Glamorgan, CF46 6LY
Project reference:	P00001231
Date of issue:	January 2017

Project Director:	Kirsten Wright
Project Manager:	Harvey Walsh
Other:	

APEM Ltd
Riverview
A17 Embankment Business Park
Heaton Mersey
Stockport
SK4 3GN

Tel: 0161 442 8938
Fax: 0161 432 6083

Registered in England No. 2530851

Report should be cited as:

"APEM (2017). Assessment of grassland fungi at Lisvane and Llanishen reservoirs. APEM Scientific Report P00001231. Dwr Cymru Welsh Water, January 2017, v2.0 Final, 39 pp."

.

Revision and Amendment Register

Version Number	Date	Section(s)	Page(s)	Summary of Changes	Approved by
1	17/01/2017	All		First draft for review	HW
2	25/01/2017	4.3, 6	13, 20	Final, minor wording changes	HW

Contents

List of Figures

List of Tables

1. Executive Summary

This report presents the findings of a survey and assessment of grassland fungi at Lisvane and Llanishen Reservoirs, Cardiff. The grassland embankments around both reservoirs are designated as a Site of Special Scientific Interest (SSSI) on account of these fungi.

The study involved a review of existing data and a new survey to assess any changes to the fungi and their habitat. The 2016 survey data confirmed that the fungi still meets the SSSI selection criteria for fungi, with a total of 20 species of waxcaps being recorded. In addition, an uncommon white form of the Pink Waxcap was observed for the first time. Olive Earth-tongue, a Biodiversity Action Plan priority species was also reconfirmed beside Lisvane Reservoir.

The 2016 study appears to indicate a general decline in the numbers and diversity of waxcap fruiting bodies over much of the grassland habitat, and mirrors the observations from studies in 2010 and 2014. The greatest numbers of fungi were observed beside Lisvane Reservoir and in the narrow strip of grassland protected by the fence around Llanishen Reservoir. Only small numbers of fungi at a very low density were found in the majority of the grassland beside Llanishen Reservoir.

The decline in abundance of fungi beside Llanishen Reservoir since the site was last managed by DCWW is likely to be the result of several factors. One significant management change is the grass cutting regime with cuttings not being removed, and an increase in the cutting height. This means that the grass is much longer than it used to be, and the long-grass cuttings do not blow away or rot down as readily as they used to. Another factor is a large increase in numbers of people visiting the site, particularly to walk dogs (dogs were excluded from the site when it was previously managed by DCWW), which results in increased inputs of nutrients, soil compaction and trampling of fungi. Locally there has also been an increase in tree cover, resulting in loss of grassland habitat as it becomes shaded by branches. The presence of the palisade fencing around Llanishen Reservoir has resulted in longer grass and increased shelter in some areas, making it too long for grassland fungi, although it has protected some areas from excessive trampling.

Recommendations are made to restore the habitat to favourable condition for grassland fungi. Ideally these would involve reinstating the former DCWW management regime, with:

(i) more frequent grass cutting

(ii) shorter cutting height

(iii) removal of woody vegetation at boundaries

(iv) reinstatement of the site as a dog-free walking area, and

(v) removal of the palisade fencing from Llanishen Reservoir.

In the short term additional habitat restoration measures are recommended including grass-collection and tree-removal. A number of alternative measures or variations of the above are also discussed. Recommendations are also made in relation to future recreational use of the site and ongoing monitoring of the grassland fungi.

2. Introduction

DCWW commissioned an ecological assessment of Lisvane and Llanishen reservoirs, focussing on the features of the two designated Sites of Scientific Interest (SSSIs). The objective of the assessment is to establish the current ecological baseline at Lisvane and Llanishen reservoirs to inform decision on suitable management of the site.

The two SSSIs are:

- Lisvane reservoir SSSI with the over-wintering bird population as its special feature;
- Llanishen and Lisvane reservoir embankments with grassland fungi as its special feature.

This particular study examines the value of the site for grassland fungi, which are the special feature of the Llanishen and Lisvane Reservoir Embankments SSSI. The objective of the study is to assess the ecological status of the site's fungi based on historical data and new surveys, and to make recommendations to inform future management decisions.

The assessment and fieldwork have been undertaken by Dr Peter Sturgess CEnv MCIEEM. Dr Sturgess first observed the waxcaps at the reservoirs in 2002 and has undertaken or assisted with many of the fungi surveys since then.

The assessment has involved informal consultations with Dusi Thomas (DCWW Environmental Manager), Sarah Revill (NRW Senior Conservation Officer), Tony Dudley (former DCWW site warden), Dr Richard Cowie (Chairman of the Reservoirs Action Group), and Dr Gareth Griffith (Reader in Mycology at Aberystwyth University) and their input is gratefully acknowledged.

3. Overview of previous fungi surveys

The history of fungi recording at the reservoirs is complex, and has been strongly influenced by changes in land ownership, access restrictions and site management that have been associated with the 'Llanishen Water' planning application to redevelop much of the site for housing. The following account attempts to broadly summarise the findings of the various surveys that have been undertaken.

The site's value for fungi was first recognised in 2002, when 17 species of waxcaps were recorded during autumn walk-over survey visits as part of data collection for the planning application for redevelopment of the site. The following autumn was very dry which limited the gathering of further information. More detailed fungi surveys were undertaken in 2004, following requests from the Countryside Council for Wales (CCW) (now Natural Resources Wales (NRW)), and this much more systematic study confirmed a total of 28 waxcap species[1]. The site's owners suspended grass-cutting through 2005, allowing the embankments to become overgrown and largely unsuitable for waxcap fruiting, with virtually no waxcaps being recorded in 2005 (pers.obs.). The site was designated a SSSI in 2005 which required grass cutting to be resumed, but the dense thatch of cuttings arising from the

[1] Hyder Consulting (2004). Fungi data collected for Llanishen Water Environmental Statement.

cut long grass was not removed. This period caused a noticeable reduction in the quality of the grass sward for fungi, and it also lost much of its botanical diversity at this time.

A thorough survey was undertaken in 2006[2] after the grass cutting had been resumed and this recorded 20 species, but noted that the number of fruiting bodies was relatively sparse when compared with the 2002 and 2004 surveys. The numbers of waxcaps were highest beside Lisvane Reservoir, where grass cutting had not been suspended for so long. A shorter survey commissioned independently by CCW in the same year[3] confirmed 15 species of waxcaps, and also noted a decline in numbers of fruiting bodies and site management since the 2004 survey.

The next systematic fungi survey was carried out in 2010[4], when a total of 27 species of waxcaps were recorded during a repeat of the 2004 study. The fungi appeared to be responding well to the reinstatement of grass cutting, even though they were still in lower numbers than in 2004, and Olive Earth-tongue was recorded for the first time. Unauthorised dog-walking has gradually increased since about 2004, and the 2010 study in particular noted that many of the waxcap specimens had been trampled and that large quantities of dog-faeces were present in the grassland. The damaging effects of the increased trampling and dog-walking was also clearly evident during a brief survey undertaken for NRW in 2014[5], when a total of 20 species of waxcaps were recorded, but again the fruiting bodies were only present in very small numbers, and much of the grassland had become extremely muddy due to heavy trampling in wet weather.

These previous studies are discussed further in the subsequent assessment sections.

4. 2016 fungi survey

4.1 Survey method

The 2016 fieldwork involved a total of 6 site visits spread out as evenly as possible between 21 October and 9 December 2016. This was to replicate the frequency of visits used during the surveys undertaken in 2004, 2006 and 2010. The exact dates of the visits were chosen according to weather conditions, aiming to avoid prolonged dry spells or heavy frosts when fungi are less likely to be fruiting. The survey commenced later in the year than some of the previous studies, which may have resulted in some species that tend to appear early in the year being missed.

The main target group for the survey was waxcap fungi (*Hygrocybe* species). However, fairy-clubs (Clavariaceae) and earth-tongues (Geoglossaceae) were recorded too since these are also good indicators of grassland habitat quality and had also been recorded during the previous studies. Most waxcaps were at least provisionally identified in the field, with specimens being collected for confirmation by microscope where necessary. All fairy-clubs and earth-tongues required confirmation by microscope.

---

[2] Hyder Consulting (2006). Fungi data collected for Llanishen Water Environmental Statement.

[3] Evans, S & Mitchel, D. (2007). Mycological Survey of Five Grassland Sites in Mid and South Glamorgan. Report to CCW: Tender No: SER/2/06-07(E).

[4] Sturgess Ecology (2011). Llanishen and Lisvane Reservoirs: Grassland fungi survey 2010. Unpublished Report to Bioscan UK Ltd.

[5] Sturgess Ecology (2014). Llanishen and Lisvane Reservoirs: Grassland fungi survey 2014. Unpublished Report to Natural Resources Wales.

Each survey used a simple walk-over/ transect-based method to search for grassland fungi, zigzagging through all of the various grassland types on the embankments, aiming to sample as much of the grassland area as possible within a survey day of approximately 5-6 hours. Survey effort was focussed on the areas of shortest grassland (where they were not too heavily trampled), as these are the most likely to have value for grassland fungi. The locations of any waxcap fruiting bodies were marked onto a survey plan during the site visit. This was generally done by eye, but the locations of any especially uncommon species were also checked using a hand-held GPS device.

Notes were made on the condition of the site for fungi, such as approximate sward height and condition, and any factors that might be affecting fungi. Digital photographs were taken to depict the habitats within the site, and any particularly notable fungi species.

4.2 Survey findings

The fungi species recorded during the 2016 survey are summarised in Table 1. The distribution of the waxcap fungi is shown in Figure 1 and non-waxcap target species in Figure 2. These plot the locations where the fruiting bodies were seen during all six visits. Note that the scale used and degree of overlapping symbols does not permit the individual species to be seen clearly in the figure, and it is mainly intended to highlight the locations where the main groups of fruiting bodies were seen. A more detailed figure is available if required.

The most productive areas for fungi in 2016 were around the northern side of Lisvane Reservoir and part of the south and western embankment, although the numbers of fruiting bodies seen in these places was much lower than most of the previous studies. The fungi fruiting bodies were generally very sparse throughout the site and were relatively hard to find. Some species were represented by a total of just one or two specimens during the 6 visits. Some of the smaller species of waxcaps (and fairy clubs and earth-tongues) were largely restricted to the less trampled top edge of the reservoir stonework, where the grass is still relatively short and untrampled. The majority of fungi were found in areas with shorter turf, often associated with mossy patches, or at the margins of previously trampled areas.

The most abundant waxcaps during 2016 appeared to be *H.calyptriformis, H.conica, H.insipida, H.pratensis* and *H.virginea*. No new species of waxcaps were recorded during 2016, but a robust pure white form of the Pink Waxcap *Hygrocybe calyptriformis f.nivea* was observed for the first time. This is significant because it highlights that there may be other fungi as yet unrecorded.

The UK Biodiversity Action Plan priority species *Microglossum olivaceum* was recorded once again, in approximately the same location beside Lisvane Reservoir that it has been recorded in previous years. Approximately 30 fruiting bodies were seen on 25 November, but their presence was short-lived, probably due to a heavy frost.

For reasons to do with the timing of commissioning, the 2016 survey commenced on 21 October, which is relatively late in the year to be likely to find some species, due to their ecology. It is possible that this timing might have resulted in some early-fruiting species being missed or under-recorded. However, a small number of typically early-fruiting species (including *H.citrinovirens* and *H.intermedia*) were still recorded. Previous studies have indicated that waxcaps at this site tend to appear a little later than other sites, typically peaking in mid-November, so the current study should have amply covered the optimum period.

Table 1 Summary of 2016 survey findings

Survey date	21 Oct	29 Oct	8 Nov	16 Nov	25 Nov	9 Dec
Waxcaps						
Hygrocybe aurantiosplendens		X	X	X	X	
Hygrocybe calciphila			X			
Hygrocybe calyptriformis	X	X	X	X		
(Hygrocybe calyptriformis f.nivea)		(X)				
Hygrocybe cantharellus		X				
Hygrocybe ceracea		X	X	X	X	
Hygrocybe chlorophana		X	X	X	X	
Hygrocybe citrinovirens	X	X				
Hygrocybe coccinea		X	X	X	X	
Hygrocybe colemanniana	X	X	X	X	X	
Hygrocybe conica	X	X	X	X	X	
Hygrocybe fornicata		X	X	X	X	
Hygrocybe insipida	X	X	X	X	X	X
Hygrocybe intermedia			X			
Hygrocybe irrigata		X	X	X		
Hygrocybe laeta				X	X	
Hygrocybe mucronella		X	X	X	X	
Hygrocybe pratensis	X	X	X	X	X	X
Hygrocybe psittacina	X	X	X	X		
Hygrocybe punicea		X	X	X	X	X
Hygrocybe quieta	X	X	X	X	X	
Hygrocybe reidii	X	X	X			X
Hygrocybe russocoriacea		X		X	X	
Hygrocybe virginea		X	X	X	X	
Total waxcap species	**9**	**20**	**19**	**18**	**15**	**4**
Other indicator species						
Clavulinopsis corniculata	X		X	X	X	
Clavulinopsis helvola		X	X	X		
Clavulinopsis laeticolor		X		X	X	
Clavulinopsis luteoalba				X		
Dermoloma cuneifolium	X				X	
Entoloma spp.		X	X	X		
Geoglossum umbratile				X		X
Microglossum olivaceum					X	

Figure 1 Summary distribution plot of waxcap fruiting bodies during 2016 survey

Figure 2 Summary distribution plot of other indicator species during 2016 survey

4.3 Assessment of fungi status in 2016

The 2016 survey confirmed that the site still supports at least 23 species of waxcaps. This total exceeds the minimum 18 species (or 12 species seen in a single visit) set out in the selection criteria for SSSIs[6]. This means that it should continue to be considered important in a national context. In a more local context, it still supports the greatest diversity of fungi in the county borough of Cardiff, and is one of only two sites in Cardiff known to support *Microglossum olivaceum*.

The numbers of fungi fruiting bodies appears to have declined significantly since the surveys carried out in most previous years, even though 2016 was generally a good year for waxcaps at other sites (pers.obs.). Although exact numbers have not been recorded systematically in the previous surveys, a decline is evident when comparing the waxcap distribution maps from previous surveys with the current distribution in Figure 1. The 2010 distribution is presented in Figure 3 and the 2014 distribution in Figure 4. The 2010 study used a similar walk-over method with 6 visits and clearly found fungi in more parts of the site than 2016. The 2014 study involved only 2 visits late in the season, but this too observed fungi in more parts of the site than 2016. (A distribution summary figure was produced from the 2004 to 2006 surveys, as part of the Llanishen Water Environmental Statement, but a copy of this document could not be found for use in this report.)

Comparison of the 2016 fungi distribution with the plans from the previous studies highlights that certain parts of the site have consistently supported higher numbers of waxcaps than others. The most diverse part of the site for waxcaps in most years has been along the northern side of Lisvane Reservoir, and this is also where the *Microglossum* has been recorded. Other areas consistently producing waxcaps are along the southern embankment of Llanishen Reservoir, and parts of the western embankment. These areas produced fewer fruiting bodies in 2016, but the appearance of a small number of waxcaps has confirmed that the mycelium of many of the species is still present. Some parts of the site have only rarely produced waxcap fungi, such as the wide strip of grassland on the eastern side of Llanishen Reservoir, and the low-lying grassland at the foot of its western embankment.

The appearance of fungi fruiting can be very inconsistent due to a range of factors, and the failure of a species to fruit in a particular location in any particular year does not mean that it is absent. The observation of *H.calyptriformis f.nivea* for the first time in 2016 illustrates this well, showing that some fungi species may be present but remain undetected for many years. However, the decline in numbers of fruiting bodies over several years, and the apparent reduction in their extent within the site (particularly much of the Llanishen western embankment and eastern slope of Lisvane Reservoir), suggests that there are problems with the current management of the grassland habitat, and the SSSI is perhaps unlikely to be considered to be in 'favourable condition' by NRW. Factors affecting grassland fungi are discussed in the following sections, and recommendations made to investigate and potentially reverse the decline.

[6] Genney D. R., Hale A.D., R.G. Woods. & Wright M. (2009). Guidelines for selection of biological SSSIs: Rationale Operational approach and criteria. Detailed guidelines for habitats and species groups . Chapter 20 Grassland fungi. Joint Nature Conservation Committee.

Figure 3 Summary distribution plot and species density of waxcaps during 2010 survey (6 visits)

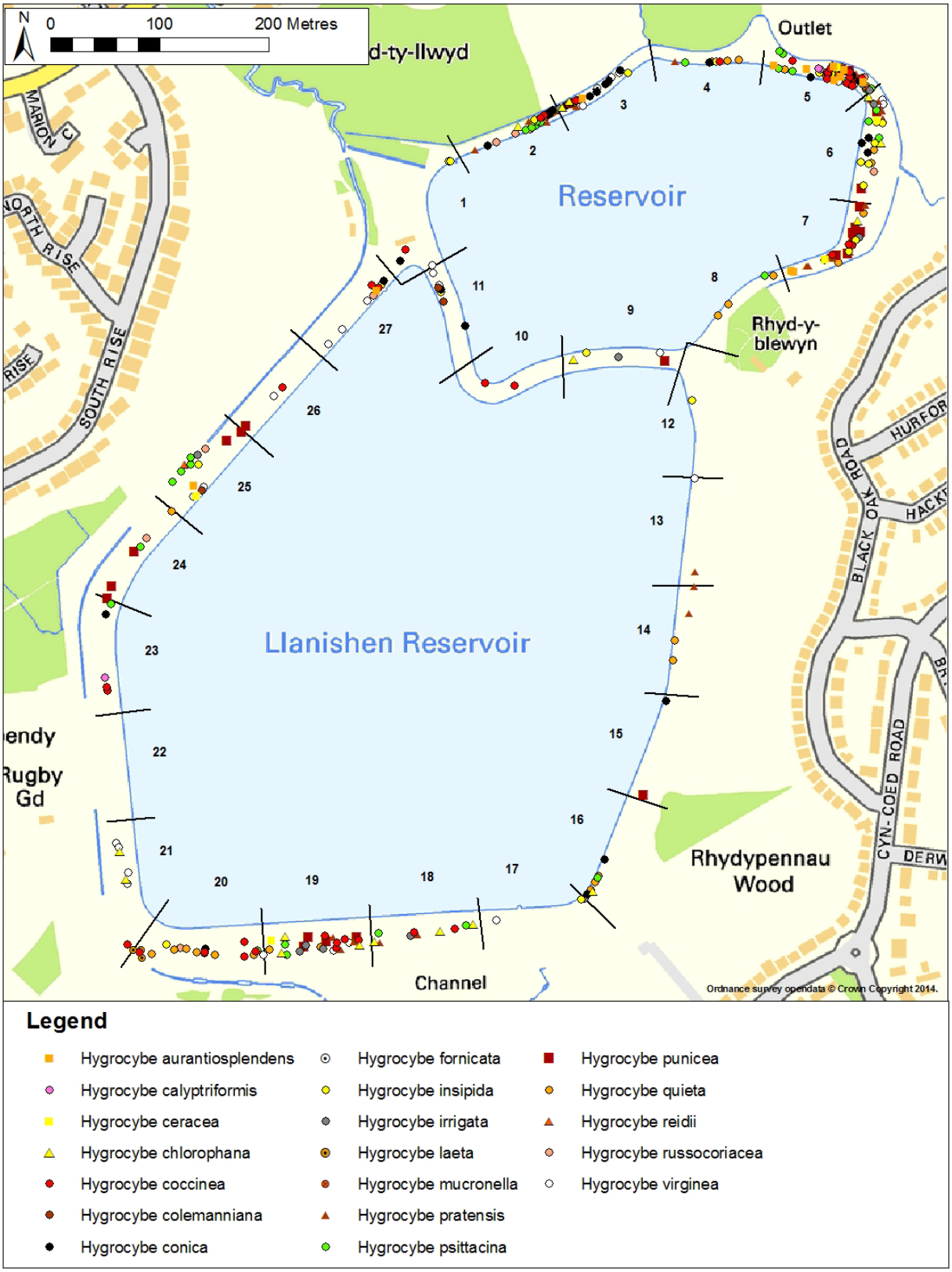

Figure 4 Summary distribution plot of waxcaps during 2014 survey (2 visits)

5. Factors affecting grassland fungi

The following section discusses the observations of factors seen during the 2016 survey that influence the suitability of the site for grassland fungi. It includes some comparison with the pre-2005 conditions under the former DCWW management regime, when waxcap numbers and diversity were much higher than they are at present.

5.1 Grass cutting

The most obvious change in the grassland in recent years is the change in the height and composition of the grass, which has become increasingly dominated by coarse tussocky grass species. Much of the 'MG5' grassland on the upper parts of the embankment slopes[7] that supported the greatest concentrations of waxcaps has changed to coarse 'MG1' grassland, or 'MG7' grassland in the more trampled areas. These changes are largely attributable to the mowing regime, where the grass is only cut three times per year but the long grass cuttings are not removed. This results in a smothering thatch of dead grass that limits growth of low-growing and annual species, and nutrient accumulation that favours tussocky grass species such as Cock's-foot, to the exclusion of fine-leaved grasses more typically associated with good waxcap grasslands. The 2016 study confirmed that there are still some areas with fine-leaved grasses and mossy turf these are generally still the best patches for fungi. These are mostly small and often associated with dense rosettes of Common Cat's-ear, or where the grass vigour is limited by shallow soil, such as beside some of the reservoir stonework.

The former DCWW cutting regime (described by former warden Tony Dudley) involved more erratic cutting but produced a much shorter grass height suitable for fly-fishing (to allow back-casting from the embankments). Prior to 1996 a local farmer used to remove a grass crop from the reservoir embankments, although this stopped after problems with fishing hooks and line in the hay. After the hay removal ceased, the site staff used to rake the cut grass from some parts of the site to produce egg-laying sites for Grass Snakes. In addition, the tractor-pulled gang-mower allowed some of the cut material to disperse from the upper parts of the embankments as it was blown down by the wind.

The new cutting equipment appears to be a covered flail that leaves the cuttings to decompose where they fall. The minimum height of the grass cut appears to be set much higher than it used to be, possibly because of the change in cutting equipment, and this leaves the base of tussocky grasses unaffected. Under the former regime some areas such as corners of banks and the crests of slopes were regularly cut down to soil level, and the bare or mossy patches of scoured ground were good places to find the smaller waxcap species and fairy clubs. The lower cut height also allowed the mosses to grow within the grass sward, and this is a factor that is often linked with good conditions for grassland fungi[8]. No parts of the site showed this variation in cut height in 2016, and mosses have largely disappeared as an important component of the grass sward.

[7] Rich, T.G.C. (2001). Botanical survey of Llanishen Reservoir. 22 August 2001. Unpublished report to Hyder Consulting, by National Museum of Wales.

[8] Bratton, J.H. (2003). Habitat management to conserve fungi: a literature review. CCW Natural Science Report No. 03/10/1. Countryside Council for Wales.

The use of the grassland by large numbers of dogs is also likely to have reduced the effectiveness of the grass-cutting. Where grass lies flat after trampling, the cut height will not remove as much of the growth. Other issues related to dogs are discussed in the next section.

5.2 Dog-walking

Historically dogs were excluded from the reservoirs under the DCWW management regime, although a small number of dog-walkers did occasionally trespass onto the site. However, from approximately 2004 dog-walkers were no longer turned away and this resulted in a very substantial increase in visitors to the site. By the time of the 2010 and 2014 surveys a number of damaging effects on the grassland fungi were becoming evident; (i) some areas have become extremely heavily trampled as dog-owners tend to walk the same routes, (ii) the large quantity of dog faeces acts as a fertiliser to the otherwise unimproved grassland, contributing to soil changes that favouring tussocky grassland plants, and (iii) many of the fungi fruiting bodies are knocked over or damaged by dogs before they mature, especially in the zone that was formerly the best areas for waxcaps, parallel to the tops of the embankments as dogs walk beside their owners.

Dogs had been excluded from the site again for several weeks prior to the 2016 survey, while DCWW closed the site to undertake repair works and tree clearance (although several dog-walkers continue to access breaks in the boundary fences). This has undoubtedly affected the survey findings, allowing more fungi to be recorded than would otherwise have been possible if the trampling by dogs had not been limited. After several weeks of the site closure the grass condition appeared much less trampled than it had done during the 2010 and 2014 surveys, but the worn paths produced no fruiting bodies of any fungi species, probably due to the heavily compacted soil. The grasses growing closest to the paths contain a high proportion of Perennial Rye-grass, which is relatively tolerant of trampling and usually indicative of high levels of soil nutrients.

Soil chemistry studies appear not to have been carried out at Llanishen Reservoir to date, but it is reasonable to conclude from the site's history, and the presence of so many waxcaps, that it has not been subject to any past input of agricultural fertilisers. Changes in the amount of soil nutrients are likely to have significant effects on waxcaps, which are typically associated with low-nutrient grasslands[9][10]. Several studies have found that the inputs of nitrogen, phosphates and potassium from dog faeces on nutrient poor soils can exert a significant fertilising effect that result in changes to plant species and soil chemistry[11], and one study showed that elevated levels of soil phosphorus can persist for at least three years even after dogs are excluded[12].

The 2014 survey findings highlighted a significant difference in the abundance, size and condition of the fungi fruiting bodies between the embankments of Llanishen and Lisvane Reservoirs. Fungi were relatively scarce around Llanishen Reservoir but present in better numbers at Lisvane. This difference appeared to be mainly attributable to the repair of the

[9] Boertmann, D. (2010). The Genus *Hygrocybe*. 2nd Revised Edition. Fungi of Northern Europe, Volume 1.
[10] Griffith.G, Easton, G.L. & Jones, A.W. Ecology and diversity of Waxcap (*Hygrocybe* spp.) fungi. *Botanical Journal of Scotland*,54, 7-22
[11] Underhill-Day, J.C (2005). A literature review of urban effects on lowland heaths and their wildlife. English Nature Research Report Number 623.
[12] Bonner,C. & Agnew, A. (1983). Soil phosphorus as an indicator of canine faecal pollution in urban recreation areas. Environmental Pollution Series B Chemical and Physical 6:145–156.

fences around Lisvane Reservoir, which excluded dogs, while uncontrolled dog-walking continued around Llanishen Reservoir. The difference between the two reservoirs is still apparent in 2016, and the decline in numbers of waxcaps on the western embankment of Llanishen Reservoir (which was one of the most diverse parts of the site in 2004 and 2006) is likely to be related to the relatively high levels of dog-walking that have continued in that area.

Physical trampling is likely to limit grassland fungi fruiting by causing soil compaction and physical damage to fungal mycelium. However, another significant observation made during the 2014 survey was the recording of several species of waxcap in areas beside Lisvane Reservoir that had previously been heavily trampled and muddy. This observation shows that the effects of trampling are not irreversible, at least in the short term and for some species.

5.3 Encroachment by woody vegetation.

The extent of the grassland area within the SSSI has been gradually reduced as trees and bushes have spread inwards from the site boundaries, and also enlargement of the isolated trees within the grassland on the western embankment. In some places, particularly beside Lisvane Reservoir, banks that were previously dominated by grasses and which supported waxcap fungi have become completely overgrown by the adjacent hedges. The increased shading and leaf-fall from this vegetation may also be affecting the grassland fungi.

Over the past few years there has been a substantial increase in tree growth on the reservoir stonework, although there has been recent work to remove the growth around Lisvane Reservoir since DCWW have resumed management of the site. The overgrown stonework has resulted in an additional sheltering effect (discussed further below for palisade fencing) and increased shading and input of leaf-litter to the grassland immediately adjacent to it.

Much of the grassland near to the site boundaries and ditches as mapped in 2001[13] has been lost to scrub encroachment. However, these were mainly damp areas and only a small number of relatively common waxcap species were recorded in them. DCWW has already made progress in cutting back scrub beside some of these features.

Parts of the stonework and concrete around both reservoirs have developed a shallow, moss-rich soil that has previously supported several species of grassland fungi, including *H.acutoconica*, *H.calciphila* and *Trichoglossum hirsutum*. However, no fungi were observed in this habitat in 2016. This is likely to be due to the changes resulting from the tree growth, and also to the spread of Mexican Fleabane around Lisvane Reservoir. It is possible that the fungi might still be present, and may recover following the recent tree removal works.

5.4 Palisade fencing

The fence around the Llanishen Reservoir stonework appears to have a number of influences on the conditions for fungi. In general the strip of grass between the fence and the stonework has been left uncut and become dominated by coarse grasses that have prevented fungi from fruiting. However, the presence of the fence has also limited the effects of trampling, and nutrient input from dogs, and the few remaining shorter patches

[13] Hyder Consulting (2001). Llanishen Reservoir. Phase 1 Habitat Survey.

beside the fence were some of the most productive areas for fungi beside Llanishen Reservoir in 2016. In fact the only records for *H.colemanniana,* and most of the records of *H.mucronella,* were in grassland that had been protected from trampling by the fence.

The presence of the fence probably has an additional influence on the fungi by altering the microclimate of the embankment tops. When the reservoir was full and there was no fence, the winds across the site could be very strong, creating harsher conditions for the plants near the top of the slopes and probably helping to remove grass cuttings, thus favouring conditions for grassland fungi.

5.5 Water-birds

The grassland strip to the south of Lisvane Reservoir is a regular roost site and feeding area for water-birds, and the presence of fencing and the security staff means that this is less disturbed by dog-walkers than other parts of the site. Grazing by geese and ducks maintains a very short grass sward, but it also results in significant enrichment through bird-droppings, and any waxcaps that appear tend to be pecked or knocked over before they mature. This strip of grass has rarely produced many fruiting bodies, even prior to 2006, but it usually produces a few. It has continued to produce small numbers of waxcaps reasonably consistently in recent years despite the apparent decline in other parts of the site. It might be speculated that the benefits of keeping the grass very short are balancing the negative effects of the nutrient input in this case.

5.6 Rabbit grazing

No signs of Rabbit grazing have been evident in any of the recent surveys, but Rabbits formerly grazed on the embankment slopes (especially west of Llanishen Reservoir) and they would have made some contribution to maintaining patches of short-grazed grass.

It is possible that Myxomatosis was responsible for the decline in the local Rabbit population. However, the presence of large numbers of dogs may also be a contributing factor.

6. Recommendations

The following section sets out a series of recommendations to restore the SSSI grassland habitat to a more encouraging condition for fungi. It also includes suggestions for further investigations and monitoring of the fungi populations, so that information on what management measures are most or least effective can be fed back into the long term maintenance plan for the site.

It is important to recognise DCWW's need to operate and maintain the site in compliance with the Reservoirs Act 1975, and to access the various apparatus and infrastructure associated with the reservoirs. It is anticipated that these requirements will not conflict with grassland management for fungi, particularly because the grassland habitat and reservoir operations have developed and co-existed over many decades already. Maintaining the embankments as short grassland is entirely in keeping with making them easily accessible for inspection as required by the Reservoirs Act.

The SSSI designation means that management should be carried out following measures agreed with NRW. In particular, following an agreed cutting regime, and avoiding any 'potentially damaging operations'. Where operational requirements necessitate use of vehicles or machinery or similar activity over grass areas within the SSSI these should always be discussed with NRW so that the work can be carried out with minimal disruption to the SSSI features.

DCWW is considering opportunities for providing access to the public for recreational use, although the precise plans for this are still not finalised. Therefore, this section includes a series of suggestions for possible ways for allowing public access while maintaining the site in favourable condition for fungi.

6.1 Grass management

Consistency of grassland management is usually a key requirement for waxcaps, and problems usually only arise where there is a change. The last 14 years or so has seen several changes in the grass management that have resulted in the current decline in condition, particularly the general increase in sward height and a change from short-grass to tussocky grass over much of the site, which has been exacerbated by accumulation of grass-cuttings and the nutrient input from dogs. The key recommendation is therefore to implement a regime similar to (or better than) the former DCWW management regime. There is very little data available over how long grassland fungi can persist in unfavourable conditions, so it is strongly recommended that **restorative grassland management should be commenced as soon as possible**.

The restoration of a short-grass sward, at least in the key areas of the embankment slopes, should be a priority for the cutting regime. This will not be easily or quickly achieved due to the high levels of nutrients held within the biomass of the existing tussocky vegetation. Restoration of short-grass habitat will inevitably involve extra effort for an initial year or so, but should become progressively easier as the vigour of the coarse grasses is gradually reduced.

The following measures are proposed:

(i) **Removal of all grass cuttings for a trial period of at least 1 year**. This will begin to lower the nutrient levels within the grassland, and prevent the damaging effects of leaving long cut grass to rot down *in situ*, where it can recycle nutrients, smother low-growing plants and favour coarse grasses. Ideally the cuttings should be removed from the site, but collecting them into piles in low-diversity areas below the embankments might also be possible. Piles of cuttings would provide suitable egg-laying sites for Grass Snakes.

(ii) **Reduce the grass-cutting height**. The current cut height appears to be ineffective at reducing the dominance of coarse grasses. This might require a change in cutting equipment. Localised scouring of the ground to bare soil should not be considered a problem; past surveys have shown scraped patches can provide suitable conditions for smaller fungi, which help to maintain the full range of fungi diversity within the site. The current cut height appears to be approximately 5-10cm, but the effectiveness of the cut may be reduced if the grass has been trampled or if grass is cut in wet weather. It may be worth attempting a cut height of 2-3cm, to cut into the dense tussocks of Cock's-foot and other coarse grasses. This will also help in removing a greater volume of grass cuttings.

(iii) **Increase the grass-cutting frequency.** To restore the embankments to short grass it would be beneficial to increase the number of cuts from three to four per year. A shorter interval between cuts should mean that the standing crop of grass is less dense, and less dead grass is generated with each cut. The addition of an extra cut should allow a cut to be carried out in late September/ early October, to provide short grass conditions for the autumn when the majority of fungi would be fruiting.

The costs of grass collection and increasing the number of cuts per year will clearly be much higher than the minimal management that has been carried out during the last few years. However, after an initial period of relatively intensive restoration management it may be possible to review the cutting regime as the height of the sward and the volume of grass cuttings are reduced. In the longer term it may be worth discussing more options for grass management with NRW. Some possibilities might be as follows:

- The potential for removing a hay or haylage-crop might be an option that could generate some income if a suitable user can be found (although this would not be viable if the grass were trampled or the crop contaminated by dog faeces or fishing tackle). The PONT hay exchange[14] may be able to suggest possible users of hay.

- Once the short-grass sward has been re-established it may not be necessary to remove the cuttings every time, especially if the number of cuts has increased. This is because there will be a much lower volume of cut material each time. Collection of cuttings increases the amount of vehicle traffic on the embankments, so removing cuttings once per year only (preferably during dry weather in summer) may be sufficient to prevent a build-up of nutrients in the long term.

- If resources do not permit grass collection over the whole site, collection from the sloping embankments should be prioritised. Hand-raking or use of grass-blowers may help to clear cuttings from the upper banks if the cuttings are small and light. If the

[14] PONT (Pori, Natur a Threftadaeth –Grazing, Nature and Heritage) is a not-for-profit organisation which exists to encourage and facilitate grazing for the benefit of the wildlife, landscape and cultural heritage of Wales.

palisade fencing around Llanishen Reservoir can be removed, the wind may help to do this naturally, as it seems to have done in the past.

- Once the initial year or so of grassland restoration cutting has been carried out, any modification of the management above the basic level of grass cutting could be undertaken on trial plots rather than being applied to the whole site.

- Reducing the dominance of coarse grasses is likely to be very beneficial to grassland plants. Once the initial restoration cutting has been completed the requirements of plants should also be considered. For example, in the precise timing of the grass cutting to allow some species to set seed.

The palisade fence around Llanishen Reservoir encloses a strip of grassland between the fence and the stone pitching that is only approximately 1m wide. This strip is difficult to access for cutting and/ or grass removal, and some parts do not appear to have been cut for at least a year. However, in the past this strip has supported a good variety of fungi species, and some are still present in the remaining shorter patches. It would clearly be beneficial to remove the fence to make the grass management easier. However, if it has to be retained, it would be worth considering introducing a small number of sheep into this area, for a minimum period of a month during the summer. The sheep could graze the narrow strip of grass between the fence and the stone pitching, eliminating the need for cutting or grass removal. They would also graze off any tree regeneration in the stone-pitching. The introduction of sheep would require the old sluice structure on the western margin to be fenced off, but little additional capital work. The palisade fence would protect the sheep from any dogs on site.

6.2 Tree management

The loss of waxcap grassland habitat to shading by trees should be relatively straightforward to address. The following measures are recommended:

(i) **All of the isolated trees on the western embankment should be removed**, and the area managed by mowing again. The recent lateral spread of these trees and associated scrub has covered several metres of grassland that has previously supported waxcaps. (In particular, a large patch of *H.coccinea* has been overgrown by the large conifer, and *H.calyptriformis, H.colemanniana, H.punicea* have been encroached upon by the two broad-leaved trees).

(ii) **The hedges adjacent to Lisvane Reservoir should be cut back to their former boundary lines**. These hedges were formerly much shorter and appear to have been at least partly managed by hedge-laying (old pleachers are still evident in some places). The grassland covered by the encroaching hedges has previously supported several species of waxcaps in the past. Cutting back the overhanging branches would also help to reduce the input of nutrients from leaf-litter to the adjacent grassland.

(iii). **All tree-growth should be removed from the reservoir stonework**. The grassland around the reservoir stonework at Lisvane Reservoir has recently been cleared, but many saplings are still present around Llanishen Reservoir. Several species of smaller fungi are associated with the shallow grassland and mosses that develop on the stonework around the reservoirs so it would be beneficial to remove all tree growth so that these can recover. It would also remove the shading effect and leaf-litter that is deposited on the adjacent grassland. In addition to tree removal, consideration should also be given to removing the

Mexican Fleabane from the walls around Lisvane Reservoir, as this has now spread around approximately 30% of the bank, and is smothering much of the grassland in these areas.

6.3 Recreational use

The exact plans for reopening the site for recreational purposes have not yet been finalised. Any plans would need to be agreed with NRW and ideally also discussed with the Reservoirs Action Group and Friends of Nant Fawr Community Woodland. Due to the complexities of the site ownership, management and access arrangements since 2002 there will undoubtedly be considerable public interest in the ongoing use of the site for recreation, so this matter will require to be carefully thought through so that the SSSI does not continue to be damaged. The following suggestions may help the discussions relating to access and recreation.

(i). **The historic (pre-2002) uses of the site for fishing and sailing are entirely consistent with favourable management for waxcaps**. Sailing would have no impact on the grassland at all, and fly-fishing would require the grassland to be maintained as short as possible. Reinstating these activities should probably be viewed as beneficial for the fungi, because they would require Llanishen Reservoir to be re-filled and the palisade fencing to be removed.

(ii) **Access on foot for members of the public would not be detrimental for fungi, provided that they keep to paths and do not bring dogs**. The site was historically used by the public for quiet recreation including walking and bird-watching, and this had relatively little impact on the grassland habitat because people generally kept to paths, and dogs were not permitted. The numbers of people accessing the site prior to 2002 were much lower than in recent years, because most visitors now come to walk dogs. If dogs were excluded again, it is likely that the numbers of visitors would be reduced to levels that do not result in excessive trampling. Cardiff has very few dog-free areas of accessible green-space, so restoring the former ban on dogs could be a positive measure for people who want access to a quiet, dog-free site.

(iii) **The north side of Lisvane Reservoir should be protected from high levels of public access**. This part of the site still retains a relatively high diversity of fungi species, probably because the fences, boundary ditches and security cabin have helped to protect it from such intensive dog-walking and trampling. Maintaining Lisvane Reservoir as an undisturbed area would protect the best remaining patch of waxcap grassland and provide an area that can be compared with the effects of public access to other parts of the site. In biodiversity terms, it would also help to retain Lisvane Reservoir SSSI as a relatively undisturbed area for birds. Ideally, the banks around Lisvane Reservoir would remain as a quiet area accessible only through the gates. If a circular walk is to be created around Llanishen Reservoir, part of the palisade fence should be repositioned so that walkers can easily get around its northern side; allowing views of Lisvane Reservoir but passing along its southern boundary.

(iv) **If dog-walking is to be permitted, it should only be allowed within certain areas.** The negative effects on the fungi of large numbers of dog-walkers have already been discussed. However, there is likely to be considerable pressure for access from local dog-walkers who have become used to using the site in recent years. Even though the site is currently closed to the public for safety reasons, many dog-walkers continue to ignore fences and signs, and some abuse of security staff has been recorded. Enforcing a complete ban on dogs is likely to be very difficult. Allowing dog-walking in certain parts of the site that are of relatively low-value for grassland fungi, subject to agreement by NRW, may provide a

solution. A plan showing the likely areas of greatest and lowest value for fungi within the SSSI, based on recent surveys, is presented in Appendix 2.

The least valuable part of the SSSI is the eastern side of Llanishen Reservoir, and it may be feasible to create a dog-walking route through this side of the site, linking with the Nant Fawr Meadows and giving good views across the reservoir. However, it is acknowledged that allowing dog-walking in some parts of the site only may make it difficult to create a circular walk around the reservoir for members of the public without dogs.

(v) **If dogs are to be allowed into any part of the site, bins should be provided for disposal of dog-faeces.** This will be necessary to prevent the problems of nutrient enrichment in the grassland and littering by discarded poo-bags. It is acknowledged that this would require resources or emptying the bins and disposal of the contents.

(vi). **The use of the site as an educational resource should be encouraged**. The site would lend itself well to use with local schools. However, given the current poor condition of the grassland and presence of low numbers of waxcaps, its educational value with respect to grassland fungi may be limited until such time as it has recovered more of its nature conservation interest. The study of any changes in waxcap fungi in response to changes in grassland management could potentially be the subject for a university research project.

(vii). **A site warden would be required.** A site warden would probably be necessary for co-ordinating the range of operational, maintenance and recreational activities that take place on the site, to serve as a point of contact with local people and other user groups, and to undertake some of the conservation management activities (as was the case prior to 2002). Given the extensive and relatively uncontrolled access that has taken place over the past few years this role would be particularly important in relation to the waxcap SSSI because a permanent site presence would be required to ensure that restrictions on dogs and access are upheld, and to check for and repair breaches in the boundary fencing.

6.4 Further survey and monitoring

Ongoing surveys are important to help determine whether the grassland in the SSSI is being maintained in a favourable condition for fungi. In the short term they will be especially significant to assess the effectiveness of any changes to grassland management. The following measures are recommended:

(i) **Fungi surveys should be undertaken during the next 2 autumns to study the effects of grassland restoration management**. Assuming that recommendations to restore the grassland to a shorter sward can be implemented prior to next season, it will be particularly important to study how the fungi respond to the changes. Changes may not be evident in the first season due to the naturally unpredictable nature of fungi, but 2 years data should begin to provide indications of whether the shorter grassland is proving beneficial for waxcaps.

(ii) **Fungi monitoring should be undertaken regularly in the longer term**. Surveys carried out every 3 or 4 years would be appropriate to check that favourable conditions are being maintained. The survey may require fewer many visits compared to some of the previous studies, provided that observations are spread through the whole fruiting season between September and early December, and that at least 1 visit is undertaken during the peak fruiting season (usually late-October to mid-November).

(iii) **Future surveys should include the early part of the fruiting season (September to early October).** Several recent studies have started relatively late in the fruiting season, and might potentially have missed some early-appearing species. Survey findings in September can be rather unpredictable, depending on the weather, but some species might be present that can only be found during early surveys. These might include some waxcaps that have not yet been recorded on the site.

(iv) **Consider the use of soil DNA analysis**. The study of fungi DNA in soils is currently undertaken as part of the research activities at Aberystwyth University, but is also occasionally used commercially. It involves the abstraction of DNA from soil samples to detect the presence of waxcaps and other grassland fungi that does not require them to produce fruiting bodies. A study of the western embankment of Llanishen Reservoir would be particularly helpful, because this previously supported the most diverse assemblage of species in the site but in recent years it has produced only a small number of fruiting bodies of very few species. A DNA analysis would also be useful to confirm whether any areas that appear to be poor for waxcaps (see Appendix 2) have indeed lost their waxcap populations. If was confirmed that waxcaps have disappeared from certain areas then these could potentially be removed from the SSSI and released for dog-walking or other potentially damaging activities.

Appendix 1: Photographs

1		Sub-optimal grass height for waxcap fungi. Coarse grassland with tussocky Cock's-foot in flower (21 October 2016).
2		Llanishen Reservoir western embankment. This was formerly one of the best areas for fungi, but very few have been recorded in recent surveys. The grass sward is much longer than it used to be and the flora diversity has also declined.
3		Closer view of grassland in one of the shorter areas of grass, showing a layer of dead grass-cuttings over the soil. The cuttings suppresses germination of annual plants and cause levels of nutrients to build up. High nutrient levels encourage a coarse grass flora and are unfavourable for waxcaps.

4		Eastern side of Llanishen Reservoir. This area is dominated by coarse grasses and has not produced many fungi for several years.
5		Llanishen Reservoir western side, showing trampled upper path and the palisade fence, and one of the trees in the grassland.
6		Scrub growth encroaching into grassland beside one of the trees on the Llanishen Reservoir western embankment.

7		Himalayan Honeysuckle encroaching into grassland on the Llanishen Reservoir western embankment. (Beneath same tree as picture above.)
8		Narrow strip of grassland between palisade fence and reservoir stonework, north of Llanishen Reservoir. This is difficult to maintain by mowing and has become dominated by coarse grasses.
9		Dense tree-growth on reservoir stone-pitching near to palisade fence west of Llanishen Reservoir. Causing localised shading of grassland, and adding to the sheltering effect of the fence.

10		Narrow strip of grassland beside palisade fence. This strip to the north-west of Llanishen Reservoir is shorter and less tussocky than most of the other parts. This relatively small area supported 10 species of waxcaps in 2016, which was the highest density observed around Llanishen Reservoir. This appears to be because it has been protected from trampling and dog-walking.
11		Dense scrub encroaching from boundary hedge north-east of Lisvane Reservoir. The scrub growth has covered several areas that formerly supported waxcaps.
12		Scrub-growth beside Lisvane Reservoir following leaf-fall. This shows the almost complete loss of grasses beneath the dense shading.

13		North-east of Lisvane Reservoir, showing muddy tracks due to operational works. The adjacent bank to the left of the picture has been completely smothered by scrub. However, small numbers of waxcaps were still present at the top of the stonework in the right of the picture.
14		Foot of bank north-east of Lisvane Reservoir, showing evidence of former hedge-laying at the old boundary. The grassland habitat would previously have extended almost up to the base of the hedge.
15		Grassland south of Lisvane Reservoir. This is heavily grazed by wildfowl, which has maintained a short grass sward. However, only small numbers of waxcaps have ever been seen in this area; possibly due to the nutrient enrichment by bird droppings.

16		Recent tree-clearing works south-east of Llanishen Reservoir. This shows the extent of the grassland that the hedge had covered. (Several species of waxcaps previously occurred in the grassland that was smothered by the hedge. Observations of fungi recovering from this sort of situation would be very helpful in making judgements regarding future management.)
17		*Hygrocybe calyptriformis f.nivea.* A robust pure white form of Pink Waxcap found on the southern embankment for the first time during the 2016 survey.
18		The usual pink form of *H.calyptriformis* on the western embankment. This is one of the species that appears able to fruit in relatively long grass. Note the dense thatch of dead grass it is growing through.

19		The BAP Priority species Microglossum olivaceum, north of Lisvane Reservoir.
	Some of the other target species observed during 2016	
20/ 21	 *Hygrocybe aurantiosplendens* in leaf litter at Lisvane northern boundary.	 *H ceracea* beside Lisvane northern boundary.
22/ 23	 *H.chlorophana* at Llanishen reservoir.	 *H.citrinovirens* beside Lisvane Reservoir northern boundary.

24/ 25	 *H.coccinea* in grassland south of Llanishen Reservoir.	 *H.colemanniana* in semi-trampled strip at foot of Llanishen Reservoir palisade fence.
26/ 27	 *H.conica* at edge of stonework beside Lisvane Reservoir.	 *H.fornicata* inside Llanishen Reservoir palisade fence.
28/ 29	 *H.insipda* at edge of stonework beside Lisvane Reservoir.	 *H.intermedia.* The only specimen observed in 2016, south of Llanishen Reservoir.

30/ 31	 *H.irrigata* beside Lisvane Reservoir eastern boundary.	 *H.laeta* in trampled grassland south-west of Llanishen Reservoir. The only specimens recorded in 2016.
32/ 33	 *H.insipda* at edge of stonework beside Llanishen Reservoir.	 *H.pratensis* north of Lisvane Reservoir.
34/ 35	 *H.psittacina* in trampled grassland west of Llanishen Reservoir.	 *H.punicea*, north of Lisvane Reservoir.

36/ 37	 *H.quieta* north of Lisvane Reservoir.	 *H.reidii* in mossy patch north of Lisvane Reservoir.
38/ 39	 *H.russocoricea* beside Llanishen Reservoir palisade fence.	 *H.virginea* beside Llanishen Reservoir stonework.
28/ 29	 *Clavulinopsis corniculata* in leaf-litter beside Lisvane Reservoir.	 *C.helvola* in short grass patch south of Llanishen Reservoir.

Appendix 2: Approximate prioritisation of fungi value within site

Note that this is a very crude summary based on observations from surveys between 2006 and 2016, to assist with planning future recreational uses for the site. Its key purpose is to provide guidance to ensure that best areas for fungi are given the highest level of protection from recreational activities that might be damaging (see section 6.3).

Appendix 3: SSSI citation details

CYNGOR CEFN GWLAD CYMRU
COUNTRYSIDE COUNCIL FOR WALES

SITE OF SPECIAL SCIENTIFIC INTEREST CITATION

CARDIFF **LISVANE RESERVOIR**

Date of Notification: 1972, 1982

National Grid Reference: ST 189822

O.S. Maps: 1:50,000 Sheet number: 171
1:25,000 Sheet number: ST 18

Site Area: 8.1 ha

Description:

A stream-fed reservoir which makes a useful refuge on the northern outskirts of Cardiff for birds including overwintering mallard, teal, tufted duck, pochard and coot; occasional divers and grebes and many passage migrants.

CYNGOR CEFN GWLAD CYMRU
COUNTRYSIDE COUNCIL FOR WALES

SITE OF SPECIAL SCIENTIFIC INTEREST CITATION

CARDIFF	**ARGLODDIAU CRONFEYDD DŴR LLANISIEN A LLYS-FAEN/LLANISHEN AND LISVANE RESERVOIR EMBANKMENTS**
Date of notification:	2005
National Grid Reference:	ST 188819
O.S. Maps:	1:50,000 Sheet number: 171 1:10,000 Sheet number: ST18 SE
Site area:	6.2 ha

Description

Llanishen and Lisvane Reservoir Embankments is of special interest for its diverse assemblage of grassland fungi, including over 25 species of waxcap *Hygrocybe spp.*

The site comprises the grassy embankments surrounding Llanishen and Lisvane Reservoirs, situated within the Lisvane district of north Cardiff, at an altitude of approximately 50m. The embankments are artificial and consist of puddle clays and coarser materials including ballast, sand, shingle and stone. Both Reservoirs are underlain by the St Maughan's formation of the Lower Devonian age, consisting of red mudstones, calcretes and sandstones. Lisvane Reservoir was constructed in 1864 to supply water to Cardiff with Llanishen Reservoir added later in 1886, to supply the rapidly expanding Cardiff Docks.

The soils overlaying the embankments are variable in depth, wetness, base richness and aspect, which have contributed to the development of a variety of grassland types. For the most part these grasslands can be described as semi-improved, varying from neutral in character, typified by species such as sweet vernal grass *Anthoxanthum odoratum*, red fescue *Festuca rubra* and common bent *Agrostis capillaris* and black knapweed *Centauria nigra* to more calcareous, characterised by *Briza media*, downy oat-grass *Helictotrichon pubescens*, birds foot trefoil *Lotus corniculatus*, rough hawkbit *Leontodon hispidus* and glaucous sedge *Carex flacca*. There are also areas of rank grassland dominated by the grasses tall fescue *Festuca arundinacea*, false oat-grass *Arrhenatherum elatius* and cock's-foot *Dactylis glomerata*.

This mosaic of grassland types has contributed to the development of a rich grassland fungal community. Species of particular note include the crazed cap *Dermoloma cuneifolium*, smoky spindles *Clavaria fumosa*, the earth tongue *Geoglossum fallax* and more than 25 species of waxcaps, *Hygrocybe aurantiosplendens, H. calyptriformis, H. citrinovirens, H. colemanniana, H. flavipes, H. fornicata, H. glutinipes, H. ingrata, H. intermedia, H. irrigata, H. punicea, H. quieta* and *H. splendidissima*. These species are distributed throughout the site, with the diversity of waxcap species being particularly noteworthy.