NPWS

Galway Bay Complex SAC

(site code 268)

Conservation objectives supporting document-
Turloughs

Version 1

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Contents

1. Introduction

1.1 Turloughs

"Turloughs" (habitat code 3180) is a priority habitat in Annex I of the Habitats Directive. A turlough is a topographic depression in karst which is intermittently inundated on an annual basis, mainly from groundwater, and which has a substrate and/or ecological communities characteristic of wetlands (Working Group on Groundwater, 2005; Tynan *et al.*, 2007). Turloughs are semi-natural habitats that are virtually unique to Ireland. They generally flood in winter and dry out in summer, but there may be other sporadic rises in response to high rainfall. Turloughs are considered to be of high conservation value for their plant, invertebrate (both terrestrial and aquatic) and bird communities (Goodwillie, 1992, 2003; NPWS, 2007, 2008; Sheehy Skeffington *et al.*, 2006). They are grass- or sedge-dominated habitats, often with areas of fen, marsh or permanent pond. Many turloughs show a distinctive zonation of herbaceous perennials which relates to the depth and duration of flooding. Turloughs intergrade into many other wetland types, from marl lakes and ponds to swamp, to fen and even to coastal lagoons and marine habitats.

The interpretation manual of EU habitats gives the following description: *"Temporary lakes principally filled by subterranean waters and particular to karstic limestone areas. Most flood in the autumn and then dry up between April and July. However, some may flood at any time of the year after heavy rainfall and dry out again in a few days; others, close to the sea, may be affected by the tide in summer. These lakes fill and empty at particular places. The soils are quite variable, including limestone bedrock, marls, peat, clay and humus, while aquatic conditions range from ultra oligotrophic to eutrophic. The vegetation mainly belongs to the alliance Lolio-Potentillion anserinae Tx. 1947, but also to the Caricion davallianae Klika 1934."* (CEC, 2007).

In Ireland, turloughs are considered to be in poor/inadequate conservation status as a result of nutrient enrichment, inappropriate grazing and drainage pressures (NPWS, 2007, 2008).

1.2 Galway Bay Complex SAC

This SAC, situated on the west coast of Ireland, comprises the inner, shallow part of a large bay which is partially sheltered from the Atlantic by the Aran Islands. The Burren karstic limestone fringes the southern and eastern sides and extends into the bay. West of Galway city, the bedrock geology is granite. There are numerous intertidal and shallow inlets, notably Muckinish, Aughinish and Kinvara Bays. A diverse range of marine, coastal and terrestrial habitats occur within the site and it is selected for 13 habitats listed on Annex I of the EU Habitats Directive. It is also listed for two species on Annex II of the Directive- harbour seal (*Phoca vitulina*) and otter (*Lutra lutra*). Inner Galway Bay SPA (4031) overlaps the SAC.

Galway Bay Complex SAC, while dominated by marine and brackish habitats, also contains wetland areas adjacent to the coast. A number of turlough-like wetlands are known to occur, to the south and south-east of the bay, associated with the Burren limestone. Table 1 below lists the known turloughs in the SAC and Appendix 1 maps their distribution in the site. The turloughs in the Galway Bay Complex show distinct inter-gradation into other wetland types. Note that there may be other turloughs within this site that have not yet been identified.

Table 1 Known Turloughs in Galway Bay Complex SAC

Name	County	Comment
Lough Rask	Clare	A small wetland with both seasonal and daily (tidal) fluctuations, this turlough may have some saline influence.
Ballyvelaghan Lough	Clare	The area to the east of the road/causeway has seasonal fluctuations and is considered a turlough.
Ballinderreen Lough	Galway	Not to be confused with Ballinderreen Turlough, which lies to the south-east of this site, and south of the N67. Ballinderreen Lough can be considered a mosaic of marl lake, swamp and turlough habitats.
Ballinacourty Turlough	Galway	The largest turlough in the SAC, this site formed the basis of the selection of the SAC for the habitat.

1.3 Conservation objectives

A site-specific conservation objective aims to define the favourable conservation condition of a habitat or species at site level. The maintenance of habitats and species within sites at favourable condition will contribute to the maintenance of favourable conservation status of those habitats and species at a national level.

Conservation objectives are defined using attributes and targets that are based on parameters as set out in the Habitats Directive for defining favourable status, namely area, range, and structure and functions.

The NPWS-funded project to assess the conservation status of turloughs[1] aims to develop indicators and targets to define favourable condition for turloughs and will help further refine the attributes and targets set out below. The Water Framework Directive (WFD) Working Group on Groundwater developed a methodology to assess the risk to turloughs from phosphorus pollution, which established provisional phosphorus thresholds for turlough flood waters and the up-gradient groundwater (Working Group on Groundwater, 2005).

Grazing is integral to the ecology of turloughs and it is important that appropriate grazing levels are maintained. Overgrazing and, in particular, undergrazing are considered significant threats to turlough conservation status. Turlough diversity will benefit from within-site spatial variations in grazing regime. Both the timing (post flood-recession) and intensity of grazing are important. Various attributes set out below (particularly sections 4.8, 4.10 and 4.11) and various authors (e.g. Goodwillie, 1992, 2003; Bond, 1997; Ní Bhriain *et al*., 2002; Moran, 2005; Regan, 2005; Ryder *et al*., 2005; Sheehy Skeffington *et al*., 2006; Moran *et al*., 2008; Kimberley *et al*., 2012) provide further information on the importance of grazing.

Note that the turloughs listed in table 1 above have not been comprehensively surveyed and attributes and targets may change/become more refined as further information becomes available.

[1] http://www.tcd.ie/Botany/research/turlough_conservation/index.php and http://www.npws.ie/researchprojects/wetlands/

2. Area

The target for habitat area is: area stable or increasing, subject to natural processes. Favourable reference area for the mapped turlough habitat within the SAC is 63.3ha (Table 2). There may be more, as yet unmapped, turloughs within this site, or the full extent of flooding and wetland communities at individual sites may not be mapped.

Appendix 2 provides maps of the extent of the four known turloughs within the SAC.

Table 2 The approximate areas of the known Turloughs in the Galway Bay Complex SAC

Name	Area	Basis
Lough Rask	3.1ha	SAC polygon
Ballyvelaghan Lough	1.9ha	SAC polygon clipped east of the road
Ballinderreen Lough	13.0ha	SAC polygon
Ballinacourty Turlough	45.3ha	SAC polygon

Ballinacourty turlough, West-southwest of Clarinbridge, can be considered to typify the definition of the habitat and is the most significant site, at approx. 45.3ha.

The SAC also includes wetland areas to the north-west of Ballinderreen village, of which Ballinderreen Lough is considered, for the purposes of these objectives, to be a turlough. Fen, swamp, reed-bed and marl pond vegetation have been described and mapped in the site, and seasonal fluctuations and turlough communities have also been documented (Curtis and McGough, 1981; Goodwillie *et al.*, 1997). Groundwater and seasonal fluctuations are clearly important drivers of the ecology of Ballinderreen Lough and, therefore, the turlough conservation objectives are appropriate to the site. Ballinderreen Lough drains, in part, via a surface flow to the Killeenaran wetland to the north. This channel discharges from the western edge of Ballinderreen Lough and runs west, then north-west.

The wetland area at Killeenaran shows some evidence of seasonal flooding, however this would appear to arise from surface water, via the large drainage channel that runs through the centre of that site and it is not considered a turlough at this time. Investigations may yet reveal that groundwater makes a significant contribution to the flooding and that flood duration is sufficient to define the site as a turlough. Information on the vegetation of the Killeenaran wetland can be found in Goodwillie *et al.* (1997). The Killeenaran wetland is considered important, however, as the channel conveys the discharge from Ballinderreen Turlough (M401152) and other areas of the Lough Fingal Complex SAC, as well as wetland areas at Drumacoo (East-northeast of Ballinderreen Lough). Drainage activities at Killeenaran could, therefore, impact on the hydrological regime of the up-gradient wetlands.

Ballyvelaghan (south of New Quay) has an area of more permanent wetland (marsh/swamp) to the west of the road/causeway, but the area to the east of the causeway (approx. 2ha) fluctuates and is considered a turlough (Eugenie Regan, pers. comm.; Sheehy Skeffington *et al.*, 2006). It is likely that the entire wetland area experienced fluctuations in the past, as suggested by the name "Ballyvelaghan Turlough", which appears on the first edition six-inch map. Modification of the causeway or natural changes in groundwater flow may have reduced fluctuations in water levels to the west of the road. Interactions with the wetland to the west of the causeway should be considered when assessing any potential impacts on or developing conservation measures for the turlough.

Lough Rask, south-east of Ballyvaughan, is a wetland with both seasonal and daily (tidal) fluctuations and is known to dry-out completely (internal NPWS files). It is likely that the site experiences some saline inputs, as *Schoenoplectus tabernaemontani* has been recorded there (Mike Wyse Jackson, pers. comm.). Abundant *Enteromorpha* sp. also suggested saline influence, and/or enrichment from local sources (Mike Wyse Jackson, pers. comm.: Jim Ryan, pers. comm.). Lough Rask can be considered a turlough with characteristics intermediate between turlough and marine habitats.

It is possible that the full extent of flooding and wetland vegetation is not contained within the SAC boundary, particularly at Lough Rask (possible area to north-east), and Ballinderreen Lough (to the south-east). An area of, possibly turlough-like, wetland also lies immediately to the south-west of the SAC boundary at Killeenaran.

3. Range

The known distribution of turloughs in Galway Bay Complex SAC is shown in Appendix 1. There may be other turloughs in the site that have not yet been mapped by NPWS.

The target for the habitat distribution attribute is: no decline, subject to natural processes.

4. Structure and functions

Structure and functions relates to the physical components of a habitat ("structure") and the ecological processes that drive it ("functions"). For turloughs these include attributes such as hydrology, soils and various water quality attributes.

4.1 Hydrological regime

Hydrology is the key driver of turlough ecology. The different turlough communities, assemblages and species are affected by various hydrological attributes. The most important of these are described below.

4.1.1 Hydrological regime: groundwater contribution

Turloughs flood mainly as a result of rising groundwater levels. The groundwater contribution exerts a strong influence on turlough ecology, notably through mineral contributions (e.g. calcium carbonate). It is, therefore, important that groundwater makes a high percentage contribution to turlough floodwaters.

The target for the attribute hydrological regime, groundwater contribution is: Maintain appropriate groundwater contribution necessary for the natural functioning of the habitat.

4.1.2 Hydrological regime: flood duration

Flood duration is considered to be the dominant hydrological driver of turlough vegetation. Flood duration is also important to turlough invertebrates. Both terrestrial and aquatic species and communities must be considered when investigating the influence of flood duration. A number of hydrological indicators of flood duration have been used in turlough studies. The recession constant (k) characterises the rate at which floodwaters recede, with a low k indicating a more gradual recession and, hence, longer flood duration (Paul Johnston, pers. comm.; Tynan, *et al.*, 2007; Naughton, 2011). The usefulness of other hydrological functions, such as gamma function, for characterising turlough hydrology is also being investigated (Paul Johnston, pers. comm.; Naughton, 2011). A team from Trinity College Dublin is currently testing the reliability of a suite of plant species as proxies for flood duration. If successful, these could be used to rapidly assess the extent and duration of flooding in turloughs. Consequently, both hydrological and vegetation indicators should be considered when measuring this attribute.

The target for the attribute hydrological regime, flood duration is: Maintain appropriate hydrological regime necessary for the natural functioning of the habitat.

4.1.3 Hydrological regime: flood frequency

Hydrological regime is highly variable among turloughs. Some turloughs demonstrate a characteristically low flood frequency (flooding just once most years for six months or more), whilst others have more dynamic water levels with higher flood frequencies (Naughton, 2011).

The target for the attribute hydrological regime, flood frequency is: Maintain natural annual temporal patterns in flood frequency.

4.1.4 Hydrological regime: flood area

The extent of flooding determines the overall area of wetland vegetation, as well as the area of each characteristic vegetation community. Flood area is also important to aquatic invertebrate communities, determining the extent of the available habitat and influencing competitive and predation interactions. A number of hydrological indicators might be used to measure the flood area, such as the average annual maximum flood area, the stage (level):area relationship, or the areal (flood) reduction rate (Porst, 2009; Naughton, 2011; Naughton *et al.*, 2012).

The target for the attribute hydrological regime, flood area is: Maintain natural temporal pattern in flood area.

4.1.5 Hydrological regime: flood depth

Flood depth is directly related to the other measures of hydrological regime (duration, area etc.). The depth of flooding could be impacted by increases or decreases in the discharge to the turlough (resulting in changes to the water level/stage) or by re-contouring the land (changing ground elevation and topography). Changes to flood depth will affect flood duration and, therefore, the vegetation communities. A number of hydrological indicators might be used to measure the flood depth, such as average annual maximum flood depth, the stage/depth:time series, or the average depth.

The target for the attribute hydrological regime, flood depth is: Maintain natural temporal and spatial patterns in flood depths.

4.1.6 Hydrological regime: permanently flooded/wet areas

Most turloughs have areas of permanent or semi-permanent flooding or saturated soils (i.e. areas that do not dry out every year). These may reflect the presence of aquitards (low permeability deposits such as peat or marl) rather than the local groundwater level during the turlough's 'dry phase'. These ponds and wet areas act as refuges for aquatic invertebrate species during the dry phase. They are particularly important to high conservation value species and assemblages, such as the moss-edge dwelling aquatic coleopteran community (Bilton, 1988; Bilton and Lott, 1991; Foster *et al.*, 1992; Bradish *et al.*, 2002). These areas also support important aquatic macrophyte communities, notably charophytes.

The target for the attribute hydrological regime, permanently flooded/wet areas is: Maintain any areas of permanent or semi-permanent flooding or water-logging.

4.2 Soil type

Turloughs are characterised by a broad range of wetland soils from mineral alluvium to peat and marl (Coxon, 1987; Goodwillie, 1992; Sarah Kimberley, pers. comm.; Kimberley, 2008). Turlough soil type is largely determined by geology, morphology and hydrology (MacGowran, 1985; Coxon, 1986). Soil type is an important driver of vegetation and influences grazing and other land management practices (Moran *et al.*, 2008; Kimberley *et al.*, 2012).

The target for the attribute soil type is: Variety, area and extent of soil types necessary to support turlough vegetation and other biota.

4.3 Soil nutrient status

Nutrient concentrations are typically low in turlough soils, but are highly variable (temporally, among soil types, and with flood duration and land-use) and exert an influence on vegetation communities (Sarah Kimberley, pers. comm.; Waldren *et al.*, 2002; Kimberley, 2008; Kimberley *et al.*, 2012; Kimberley and Waldren, 2012).

The target for the attribute soil nutrient status is: Nutrient status (phosphorus and nitrogen concentrations) appropriate to soil types and vegetation communities.

4.4 Physical structure: Bare ground

Bare ground in turloughs occurs naturally in areas with long flood duration and late drying and where fine sediments (alluvium) are deposited by the floodwaters. Trampling by grazers can also result in areas of bare ground. Bare ground is important for certain vegetation communities, such as *Chenopodion rubri* (Habitats Directive Annex I habitat 3270), which is dominated by short-lived annuals, including the rare *Callitriche palustris*, *Limosella aquatica* and *Rorippa islandica*. It is also important to invertebrate communities, notably ground beetles (Regan, 2005a; Sheehy Skeffington *et al.*, 2006).

The target for the attribute Physical structure, bare ground is: Sufficient wet bare ground, as appropriate.

4.5 Chemical processes: Calcium carbonate deposition

Calcium carbonate ($CaCO_3$) deposition is a feature of very many turloughs (Coxon, 1994; Goodwillie, 2003). Both physical and biological processes clearly play a part in precipitating $CaCO_3$ from saturated/ super-saturated groundwater, as evidenced by deposits on turlough vegetation after flood recession (Goodwillie, 2003; Jim Ryan, pers. comm.). While it may appear difficult to change $CaCO_3$ precipitation, it could be affected by drainage activities in the turlough or the zone of contribution (groundwater catchment) impacting the $CaCO_3$ concentration in the floodwater, or by changes to biological communities, impacting the precipitation processes.

The target for the attribute chemical processes, Calcium carbonate deposition and concentration is: Appropriate $CaCO_3$ deposition rate and/or soil concentration.

4.6 Water quality

Turloughs, being groundwater fed, are typically associated with high water quality. This is demonstrated by naturally low dissolved nutrients, clear water and low algal growth. Water quality can be measured by the following attributes:

4.6.1 Water quality: nutrients

The WFD Working Group on Groundwater developed a methodology to assess the risk to turloughs from phosphorus pollution, which established provisional phosphorus thresholds for turlough flood waters and the up-gradient groundwater (Working Group on Groundwater, 2005). Two total phosphorus (TP) thresholds were set for the turlough water, depending on the site's fertility and sensitivity to phosphorus enrichment. A threshold of ≤10µg l^{-1} TP was set for the least fertile ('extremely sensitive') turloughs as defined by the vegetation communities, and a threshold of ≤20µg l^{-1} TP for all other turloughs. These values were based on the Phosphorus Regulations' standards for TP in Irish lakes, which indicate that when mean TP is ≤10µg l^{-1} a lake is oligotrophic and >10 to ≤20µg l^{-1} mesotrophic (McGarrigle *et al.*, 2002, Appendix I). Work undertaken by TCD since this time has clearly demonstrated that turloughs behave like lakes in terms of their phytoplankton biomass and their TP:phytoplankton biomass (chlorophyll *a*) relationship (Norman Allott, pers. comm.; Cunha Pereira *et al.*, 2010). Their findings support the use of 10µg l^{-1} TP and 20µg l^{-1} TP thresholds, however, the natural background levels for all turloughs are likely to be <10µg l^{-1} (Norman Allott and Catherine Coxon, pers. comm.).

While it may ultimately be necessary to set site-specific TP targets for turloughs, the categorisation developed by the WFD Working Group on Groundwater will be used in the interim, with more oligotrophic sites dominated by fen and other sedge-rich vegetation of low-fertility and high species diversity having a target of ≤10µg l^{-1} TP. See Working Group on Groundwater (2005) for more information on categorising the sensitivity of turloughs.

The target for the attribute water quality, nutrients is: Maintain average annual TP concentration of ≤10µg l^{-1} TP, or ≤20µg l^{-1} TP, as appropriate.

These TP targets may not be appropriate for Lough Rask, owing to the apparent saline influence. The information on nutrients in lagoons may provide additional guidance (see the Galway Bay Complex SAC Conservation Objectives Supporting Document – Lagoons).

4.6.2 Water quality: colour

Colour is typically low in turlough floodwaters, however drainage of peatland in the Slieve Aughty Mountains is believed to have increased the colour in Blackrock, Lough Coy, Garryland and Caherglassaun turloughs and to have altered the nutrient-algal biomass relationship and phytoplankton species composition (Norman Allott, pers. Comm.; Cunha Pereira *et al.*, 2010). Reduced light penetration is the most likely causative factor, although sequestration of ions can also affect phytoplankton growth (Norman Allott, pers. Comm.; Cunha Pereira *et al.*, 2010). Increased water colour could also impact on the primary productivity of rooted plants, either the truly aquatic plants or those wetland species that can grow even when flooded. All TCD study turloughs, other than those on the Gort-series (72-85 mg/L PtCo), had colour of < 48 mg/L PtCo, with the Burren turloughs all ≤14 mg/L PtCo (Cunha Pereira *et al.*, 2010.).

The target for the attribute water quality, colour is: Maintain appropriate water colour.

4.6.3 Water quality: phytoplankton biomass

Phytoplankton biomass as chlorophyll *a* is not significantly lower in turloughs than that found in permanent lakes (Cunha Pereira *et al.* 2010). Peak chlorophyll *a* concentration was recorded in winter in the TCD study turloughs (Norman Allott, pers. Comm.; Cunha Pereira *et al.*, 2010). It is probable that the decline in phytoplankton biomass in spring in turloughs is, at least in part, the result of grazing by zooplankton, whose development is likely dependent on temperature triggers.

The targets below are based on the OECD fixed boundary system for annual mean and annual peak chlorophyll *a* (OECD, 1982). Lower thresholds apply for the more oligotrophic and sensitive sites. See also Section 4.6.1 above, water quality: nutrients and the Working Group on Groundwater (2005) for more information on categorising the sensitivity of turloughs.

The chlorophyll *a* standards in the European Communities Environmental Objectives (Surface Water) Regulations (S.I. 272 of 2009) could not be adopted as they are based on "growing season (March to October) mean values[2]", which includes a turloughs 'dry phase'. In addition S.I. 272 of 2009 states that the EQR boundary conditions are not yet developed for shallow calcareous lakes, which is the lake type most similar to turloughs.

The target for the attribute water quality, phytoplankton biomass is: Maintain appropriate cholorophyll *a* concentrations as follows:

Turlough type	**Annual mean cholorophyll *a* concentration** µg l^{-1}	**Annual maximum cholorophyll *a* concentration** µg l^{-1}
Oligotrophic turloughs (more sensitive)	<2.5µg l^{-1}	≤8µg l^{-}
Other turloughs	<8µg l^{-1}	<25µg l^{-}

[2] a minimum of four samples is required, distributed throughout the growing season.

4.6.4 Water quality: epiphyton biomass

Patches of filamentous algae are a common occurrence in turloughs, however extensive algal mats are only found in turloughs with high average TP concentrations (i.e. $\geq 20\mu g\ l^{-1}$) (Normal Allott, pers. comm.). The filamentous forms recorded include *Oedogonium*, *Spirogyra* and *Mougeotia* species (Normal Allott, pers. comm.). A few turloughs with high TP did not develop extensive algal mats, at least partly because of high water colour (Normal Allott, pers. comm.).

As a general rule, therefore, higher TP concentrations increase epiphyton production in turloughs. Owing to the fact that epiphyton is typically deposited onto the vegetation as the floodwaters recede, the decomposition of these algae is a pathway for nutrients from water to soil and rooted vegetation.

The target for the attribute water quality, epiphyton biomass is: Maintain trace/ absent epiphyton as algal mats (< 2% cover).

4.7 Active peat formation

Peat formation is not a feature of all turloughs, but is associated with sedge-rich, fen-type vegetation communities. The duration of flooding is the key determinant of peat formation in turloughs. The water level needs to be slightly below to above the soil surface for approximately 90% of the time for peat to form (Jim Ryan, pers. comm.). Active peat formation can be threatened by drainage and other earth movements, as well as changes in hydrological regime. Note: peat formation in turloughs can be affected by natural changes in hydrology (Coxon and Coxon, 1994).

The target for the attribute active peat formation is: Active peat formation, where appropriate.

4.8 Vegetation composition: vegetation communities

The vegetation of turloughs has been described and classified a number of times, notably by Goodwillie (1992, 2003); Goodwillie *et al.* (1997); O'Connell *et al.* (1994); MacGowran (1985); Regan *et al*. (2007) and Sharkey (2012). The conservation value of the described vegetation communities was considered by most of these authors (e.g. Goodwillie, 1992; O'Connell *et al.*; 1994, Regan, 2005a; Sharkey, 2012). The WFD Working Group on Groundwater classified sensitive vegetation communities by assigning Ellenberg N (fertility) values (Hill *et al.*, 1999) to data from Goodwillie (1992); Goodwillie *et al.* (1997) and NPWS surveys (Working Group on Groundwater, 2005).

The TCD integrated turlough project has identified the following characteristic turlough communities as positive indicators (turlough-type dependent): *Eleocharis acicularis* community, *Eleocharis palustris-Ranunculus flammula* community, Limestone grassland community, *Carex* fen (*Molinia caerulea-Carex panicea* community), *Schoenus nigricans* fen (Steve Waldren, pers. comm.; Sharkey, 2012). Flooded woodland and pavement communities were also considered to be positive indicators. Using the turlough vegetation classification system developed by Goodwillie (2003), the following can be considered positive indicator communities: 2A, 2B, 3A, 3B, 4B, 6A, 6B, 7B and 8E. Further work on identifying sensitive and high conservation value vegetation communities is on-going (Steve Waldren, pers. comm.).

Turlough vegetation communities also support invertebrate species and assemblages. The association between the turlough moss-edge water beetle assemblage and moss-rich fen vegetation communities is particularly notable.

No vegetation maps are available for Lough Rask, Ballyvelaghan Turlough or Ballinacourty Turlough.

Internal NPWS files contain a brief description of the vegetation of Lough Rask as follows: "*Potentilla anserina* is one of the most abundant plants in the wetland. *Galium palustre* and *Carex* spp. (*otrubae*) also occur."

Ní Bhriain (1999) studied Ballyvelaghan turlough. Notes in internal NPWS files record the following species: *Mentha aquatica*, *Filipendula ulmaria*, *Equisetum* spp., *Schoenoplectus lacustris*, *Typha latifolia*, *Menyanthes trifoliata* and *Potamogeton* spp., many of which may be found in the more permanent wetland to the west of the road.

The vegetation of Ballinderreen Lough is described in Curtis and McGough (1981) and consists of swamp, marsh, fen and turlough communities. Goodwillie *et al.* (1997) map and describe Ballinderreen Lough as having dense *Phragmites australis*, scattered *Cladium mariscus* and dry-ish *Schoenus nigricans* fen.

Ballinacourty Turlough displays a typical turlough vegetation zonation ranging from wetland species near the base of the turlough to species of wet grassland close to the limit of flooding. *Carex* spp., *Agrostis stolonifera* and *Potentilla anserina* are prominent (internal NPWS files). The wettest areas of the turlough are also rich in charophytes and pondweeds (Micheline Sheehy Skeffington, pers. comm.). Ballinacourty is likely to have a number of swallow holes/estavelles and contains marl (Micheline Sheehy Skeffington, pers. comm.). *Juncus gerardii* has been recorded in the turlough and was probably brought in from an adjacent salt inlet and marsh by birds (Micheline Sheehy Skeffington, pers. comm.). This species is surviving without any direct saline or brackish water inputs (Micheline Sheehy Skeffington, pers. comm.).

The target for the attribute vegetation composition, area of vegetation communities is: Maintain area of sensitive and high conservation value vegetation communities/units.

4.9 Vegetation composition: vegetation zonation

Sheehy Skeffington *et al*. (2006) provide a good commentary and summary of the studies on turlough vegetation zonation. Praeger (1932) was one of the first to record the zonation from dry soil species at the turlough margins to amphibious and aquatic species in the areas with the longest flood duration. This zonation has been recorded by many authors (Ivimey-Cook and Proctor, 1966; O'Connell *et al*., 1984; Goodwillie, 1992; Goodwillie *et al*., 1997). Goodwillie (2003) discusses the influence of flood duration, the timing of flooding and other hydrological characteristics on vegetation zonation.

Maintaining a diversity of vegetation zones (community patches) also helps support invertebrate diversity.

The target for the attribute vegetation composition, vegetation zonation is: Maintain the vegetation zonation/mosaic characteristic of the site.

4.10 Vegetation structure: sward height

Vegetation height varies over time in turloughs, as a result of the timing of flood recession and the plants' growth periods, as well as the grazing regime. Vegetation diversity can be maximised by employing a variable grazing regime across the turlough. Variation in vegetation height is also important to invertebrate communities, with some species being dependent on bare soil, some associated with grazed, short vegetation, whilst others, notably Diptera and Lepidoptera, require taller herbaceous vegetation and scrub, respectively (Bond, 1997; Good and Butler, 2001; Ní Bhriain *et al*., 2002; Moran, 2005; Regan, 2005a; Ryder *et al*., 2005; Sheehy Skeffington *et al*., 2006).

Moran *et al*. (2008) state "Given that different species of both plants and animals will respond differently to differing management conditions, maintenance of heterogeneity is vital for the maintenance of maximum biodiversity".

The target for the attribute vegetation structure, sward height is: Sward heights appropriate to the vegetation unit, and a variety of sward heights across each turlough.

4.11 Typical species

As wetlands with distinct terrestrial and aquatic phases, turloughs have a range of typical species that can broadly be divided into wetland and aquatic species. In listing the typical species for the various groups below, strong emphasis has been placed on those that are indicative of good condition in turloughs (positive indicator species) and/or are known to be restricted to or have most occurrences in turloughs (characteristic species). The species lists highlight the rare and threatened species found in turloughs.

4.11.1 Typical species: terrestrial, wetland and aquatic plants

Table 3 lists the typical turlough plant species. It updates the typical species list produced by NPWS in 2007. The list includes the species typical of the Annex I habitat 'Rivers with muddy banks with *Chenopodion rubri* p.p. and *Bidention* p.p. vegetation' (3270), which is a community of short-lived annual species associated with turloughs in Ireland. It should be noted that habitat 3270 has not yet been recorded in the turloughs in the Galway Bay Complex SAC. Various botanical and review studies list characteristic turlough plants (e.g. Goodwillie, 1992, 2003; Goodwillie *et al*., 1997; Sheehy Skeffington *et al*, 2006; Sharkey, 2012).

The TCD integrated turlough project has identified the following as positive turlough indicator species: *Potentilla fruticosa, Viola persicifolia, Teucrium scordium, Limosella aquatica, Plantago maritima, Rorippa islandica* and *Frangula alnus* (Steve Waldren, pers. comm.).

Lockhart *et al*. (2012a) noted that *Cinclidotus fontinaloides* is characteristic of turloughs and that the rare *Pseudocalliergon lycopodioides* and *Drepanocladus sendtneri* can be locally abundant in turloughs. Some of the best, fen-vegetation-rich turloughs support *Pseudocalliergon trifarium* (Lockhart *et al*., 2012a).

In addition to the typical species of habitat 3270 listed in Table 3, a number of species are associated with the habitat, including: *Atriplex prostrata, Gnaphalium uliginosum, Rorippa palustris, Persicaria hydropiper*, *Chenopodium rubrum, Juncus bufonius* and, *Bidens tripartita*.

Table 4 lists other more widespread vascular plant species that are commonly encountered in turloughs, often at high cover abundance.

Further investigation into the charophyte flora and other aquatic macrophytes of turloughs is required.

The target for the attribute typical species, terrestrial, wetland and aquatic plants is: Maintain typical species within and across sites

Table 3 The typical plant species of turloughs. Species indicated by * are considered turlough specialists, though not necessarily restricted to turloughs. † indicates typical species of habitat 3270. Regional Red List status (VU= vulnerable; NT= near threatened) is given, where relevant, as a superscript (bryophytes only) (Lockhart *et al.*, 2012b).

Angiosperms:
Dicots: *Callitriche palustris**†, *Frangula alnus* (prostrate form*), *Galium boreale*, *Limosella aquatica*†*, *Persicaria minor*†, *Plantago maritima*, *Potentilla fruticosa**, *Ranunculus repens* (form with highly dissected leaves*), *Rhamnus cathartica*, *Rorippa islandica**†, *Teucrium scordium**, *Viola persicifolia**
Monocots: *Alopecurus aequalis*†, *Carex viridula* agg., *Eleocharis acicularis*†, *Schoenus nigricans*
Bryophytes:
Mosses: *Cinclidotus fontinaloides, Drepanocladus sendtneri* ^{NT}, *Pseudocalliergon lycopodioides* ^{VU}, *Pseudocalliergon trifarium* ^{VU}
Liverworts: *Riccia cavernosa*†
Pteridophytes:
Ophioglossum vulgatum

Table 4 Widespread plant species commonly found in turloughs, frequently at high abundance. Species indicative of oligotrophic conditions are given a ‡.

Angiosperms:
Dicots: *Baldellia ranunculoides‡, Filipendula ulmaria, Hydrocotyle vulgaris*, *Leontodon hispidus*, *Littorella uniflora‡, Mentha aquatica*, *Myosotis scorpioides, Persicaria amphibia*, *Persicaria hydropiper, Potamogeton gramineus, Potamogeton polygonifolius‡*, *Potentilla anserina*, *Potentilla reptans*, *Prunus spinosa*, *Ranunculus flammula*, *Ranunculus trichophyllus*, *Rumex acetosa*, *Scorzoneroides autumnalis*, *Thymus polytrichus*, *Trifolium repens*, *Viola canina*
Monocots: *Agrostis stolonifera, Carex hirta, Carex hostiana, Carex nigra, Carex panicea, Deschampsia caespitosa, Eleocharis multicaulis‡, Eleocharis palustris, Eleogiton fluitans‡, Festuca arundinacea, Festuca rubra, Glyceria fluitans, Juncus articulatus, Juncus bulbosus‡*, *Molinia caerulea, Phalaris arundinacea, Poa annua*
Bryophytes:
Fontinalis antipyretica, Scorpidium revolvens

4.11.2 Typical species: aquatic invertebrates

NPWS (2007) provided a draft list of typical aquatic invertebrate species of turloughs, which has recently been updated (see Table 5), and the available information on this group is reviewed by Sheehy Skeffington *et al*. (2006). The species of greatest conservation importance in turloughs include the rare chydorid, *Eurycercus glacialis* (see Duigan and Frey, 1987a, b; Reynolds, 1997, 2000; Reynolds and Marnell, 1999; Reynolds et al., 2004), the copepod *Diaptomus castor* (see Ali et al., 1987; Reynolds, 1997), the near threatened odonate *Lestes dryas* (see Nelson and Thompson, 2004; Nelson *et al.*, 2011), and the characteristic water beetle species *Agabus labiatus*, *Graptodytes bilineatus*, *Berosus signaticollis* and *Dryops similaris* (see Bilton, 1988; Bilton and Lott, 1991; Foster *et al.*, 1992; Bradish *et al.*, 2002; Foster *et al.*, 2009). As well as these rare and threatened water beetle species, typical aquatic coleopteran species include: *Haliplus obliquus, Agabus nebulosus, Rhantus frontalis, Hygrotus impressopunctatus, Helophorus minutus, Laccobius colon, L. minutus,* and *Ochthebius minimus* (Garth Foster, pers. comm.). *Bagous brevis* is a critically endangered aquatic weevil that feeds on *Ranunculus flammula*. The only recent records for this species are from Knockaunroe turlough (Morris, 1985; Bilton and Lott, 1991; Foster *et al.*, 2009). *Siphlonurus armatus* is a critically endangered mayfly, the only recent record of which is from a turlough (Kelly-Quinn and Regan, 2012). Both these species and their potential association with turloughs require further study.

Characteristic turlough molluscan species include: *Stagnicola fuscus*, *Galba truncatula*, *Radix balthica*, *Anisus leucostoma*, *Oxyloma elegans* and *Pisidium personatum* (Evelyn Moorkens, pers. comm.). High quality turloughs contain a good mixture of these species in relatively even abundance (i.e. no one species dominating) (Evelyn Moorkens, pers. comm.). *Valvata cristata* and *Armiger crista* may also be present but restricted to the more stable areas of water (Evelyn Moorkens, pers. comm.).

The target for the attribute typical species, aquatic invertebrates is: Maintain typical species within and across sites.

Table 5 Typical aquatic invertebrate species of turloughs. This is an updated version of the table in NPWS (2007). The species included are characteristic and/or indicative of good quality in turloughs. Those species indicated by * have a strong association with turloughs, with most/all records for that species in Ireland coming from turloughs. Regional Red List status is given, where relevant, as a superscript (CR= critically endangered, EN= endangered; VU= vulnerable; NT= near threatened).

Aquatic invertebrates:
Plathyhelminthes, Turbellaria: *Polycelis nigra;* **Crustacea, Cladocera:** *Alonella excisa, Alona rustica, Alonopsis elongate, Alona affinis, Eurycercus glacialis*,* **Crustacea, Copepoda;** *Diaptomus castor;* **Insecta, Odonata:** *Lestes dryas*, Sympetrum sanguineum*; **Insecta, Coleoptera:** *Agabus labiatus** ^{NT}, *Agabus nebulosus, Bagous limosus* ^{CR}, *Berosus signaticollis** ^{EN}, *Dryops similaris** ^{NT}, *Graptodytes bilineatus** ^{NT}, *Haliplus obliquus, Haliplus variegates* ^{VU}, *Helophorus minutus, Helophorus nanus* ^{VU}, *Hygrotus impressopunctatus, Laccobius colon, Laccobius minutus, Ochthebius minimus, Rhantus frontalis*.

4.11.3 Typical species: other invertebrates

NPWS (2007) provides a draft list of typical terrestrial invertebrate species of turloughs (see Table 6). The EU Interpretation Manual (CEC, 2007) lists the following terrestrial invertebrate species as characteristic of turloughs: *Agonum lugens, A. livens, Badister meridionalis, Blethisa multipunctata* and *Pelophila borealis* (dry phase).

The available information on terrestrial invertebrates was reviewed by Sheehy Skeffington *et al*. (2006). They state "The terrestrial invertebrate fauna of turloughs includes several rare species and communities. Yet to date only some faunal groups have received much attention. The beetles and butterflies have been described to some extent, but the remaining terrestrial orders are poorly documented."

Terrestrial Coleoptera have been recorded by a number of authors (e.g. Speight, 1976, 1977, Lott and Foster, 1990, Lott and Bilton 1991, Anderson, 1997, Owen, 1997, Good and Butler, 2001, Ní Bhriain *et al*., 2002, Lott, 2003, Moran *et al*., 2003, Regan and Anderson, 2004, Moran, 2005, Regan, 2005 a and b, Regan and Moran, 2005).

Bond (1997) noted that no lepidopteran species were exclusively associated with turloughs, but that the upper turlough zones and, especially, fringing scrub had high diversity and hosted some scarce and rare species. The frequency and longevity of flooding is probably a limiting factor for many of the terrestrial species and many of the claimed associations of species with turloughs remain unverified. For example, several species of Lepidoptera feed on *Rhamnus,* which tends to grow on pavement near and at the upper margins of turloughs, and so have been associated with the habitat. There is no evidence, however, that these species have any requirement for the turlough habitat itself. The Lepidoptera species listed in Table 6 are those which have been associated with turloughs and which feed on wetland species of plant. A possibly un-described species of micromoth of the genus *Elachista* (Elachistidae) was recently found at Coolorta Turlough in the Burren, the caterpillars of which were feeding on *Cladium mariscus* (Phil Sterling, pers. comm.).

Insufficient and lack of comprehensive survey of other groups limits selection of other typical species to a few. Morris (1974) provides an account of the Auchenorrhyncha (Hemiptera) of the Burren which refers to species associated with wetlands. However, work such as this needs to be repeated before definitive turlough associations can be made.

The target for the attribute typical species, other invertebrates is: Maintain typical species within and across sites.

Table 6 The typical terrestrial invertebrate species of turloughs (NPWS, 2007). Species indicated by * have a strong association with turloughs, i.e. most/all records for that species in Ireland are from turloughs.

Terrestrial invertebrates:
Diptera, Sciomyzidae: *Pherbellia nana, Colobaea distincta, Ilione albiceta, Pherbina coryleti*; **Lepidoptera, Crambidae:** *Paraponyx stratiotata*; **Lepidoptera, Tortricidae:** *Bactra furfurana;* **Lepidoptera, Gelechiidae** *Monochroa lutulentella;* **Lepidoptera, Noctuidae:** *Deltote uncula;* **Coleoptera, Carabidae:** *Blethisa multipunctata, Chlaenius nigricornis, Pelophila borealis, Agonum piceum, Carabus granulatus, Loricera pilicornis, Pterostichus nigrita, Bembidion clarkii, Agonum muelleri, Bembidion aeneum, *Agonum lugens, *Platynus livens, *Badister meridionalis, *Badister peltatus*; **Coleoptera, Staphylinidae:** *Philonthus furcifer;* **Coleoptera, Silphidae**: *Thanatophilus dispar.* **Orthoptera, Tetrigidae** *Tetrix subulata*; **Orthoptera, Acrididae** *Chorthippus albomarginatus* **Heteroptera, Saldidae** *Saldula opacula*

4.11.4 Typical species: birds

The aquatic phase of turloughs has long been recognised as of importance for wintering waterbirds (Buckley and McCarthy, 1987; Buckley, 1993; Madden and Heery, 1997; Crowe, 2005). Turloughs can provide rich feeding grounds, and can also be important roosting areas. Waterbird usage may also contribute to the colonisation or re-colonisation of turloughs by certain invertebrate species (see Frisch *et al.,* 2007). Turloughs near the coast, such as those in the Galway Bay Complex SAC, and those near large lakes, generally have higher numbers of waterbirds than the Burren or land-locked turloughs. Coastal turloughs can be particularly important for feeding and roosting during high tides and stormy seas. The more oligotrophic turloughs, however, tend to host fewer birds.

Regular counts of non-breeding waterbirds at Ballinacourty Turlough are undertaken as part of the Irish Wetland Bird Survey (I-WeBS). This turlough is known as Ahapouleen Turlough (Clarinbridge) on the IWeBS database. Table 7 sets out peak annual counts for a series of nine winter seasons. The presence of shoveler is particularly noteworthy, as it is regularly recorded here in nationally important numbers. This species, a dabbling duck, is well adapted to feed on zooplankton on or near the water surface, as well as being able to feed by upending in shallow waters for other invertebrates and for plant material.

Table 7 IWeBS count data for Ballinacourty (Ahapouleen) Turlough. Data courtesy of Olivia Crowe, BirdWatch Ireland.

Species	2002/03	2003/04	2004/05	2005/06	2006/07	2007/08	2008/09	2009/10	2010/11	Maximum count
Mute Swan	4		3	2	3	3	2	2	4	4
Shelduck		1		1						1
Wigeon	146	124	45	135	207	35	144	240	82	240
Teal	148	5	39	58	99	10	74	70	58	148
Mallard	14	18	2		23	10	8		16	23
Pintail				18			9	7	16	18
Shoveler	24	14	61	47	183	69	119	215	35	215
Pochard								3		3
Tufted Duck	26		32		8	4	29	27		32
Red-breasted Merganser	1									1
Little Grebe				2	8	3	5	2	5	8
Great Crested Grebe		1								1
Cormorant		4		0						4
Grey Heron		7	3		2		2			7
Moorhen							1		1	1
Coot						15	46	25	33	46
Oystercatcher	13	5			36	5			7	36
Golden Plover	1200						1500			1500
Lapwing	373		376	220	141	40	362	80		376
Dunlin									1	1
Snipe	1						8			8
Black-tailed Godwit	2				1		870			870
Bar-tailed Godwit						3				3
Curlew	2	27	3		40		1	35	6	40
Greenshank								1		1
Redshank	1	1				2	1	1	1	2
Black-headed Gull	10	3	3	15	28	8	16	5	1	28
Common Gull	55	15	116	9	90	20	280	70	2	280
Herring Gull			1							1
Great Black-backed Gull			4					1	1	4

The bird data also indicate that there is some movement between Ballinacourty Turlough and the nearby coastal areas of Galway Bay (Inner Galway Bay SPA). Species like bar-tailed godwit, oystercatcher, redshank and greenshank show a strong coastal preference during the winter months, so it is possible that these species use Ballinacourty as a roost site during high tide and/or inclement weather.

Infrequent but large numbers of golden plover have been recorded here. Lapwing occur at this site more frequently, but in smaller numbers. Both of these species forage for soil invertebrate in grassland areas and other agricultural habitats and then congregate in wetland areas to roost. It is likely that these species find a suitable roosting resource close to the turlough water's edge, but may also forage in the areas of the turlough that are not inundated with water.

During the high tide period, black-tailed godwit can regularly supplement their intertidal feeding by foraging on wet grassland habitats for invertebrates. During the 2008/09 period, an internationally important flock was recorded on Ballinacourty Turlough in November. As this species was not recorded at this site for the rest of the winter period, it is likely that this was a passage flock that availed of the suitable roosting and/or feeding resources here en route to overwinter at a more southerly resort.

The target for the attribute typical species, birds is: Maintain typical species within and across sites.

4.12 Fringing habitats

Marginal woodland and scrub, as well as fringing limestone pavement and semi-natural grasslands are important for terrestrial invertebrates, particularly Lepidoptera (see also Section 4.11.3 above). *Rhamnus cathartica* (Purging Buckthorn) appeared to be of special significance (Bond, 1997). The Irish Annulet (*Odontognophos dumeteta*) is one such rare species that could have an association with the fringing habitats of turloughs, as it feeds on *Rhamnus cathartica*. These fringing habitats are also important over-wintering sites for many terrestrial coleopteran species that occupy the turlough during the dry phase (Good and Butler, 2001, Lott, 2003).

Semi-natural and natural fringing habitats are also likely to act as seed/propagule source areas for turlough plant species.

Fringing grasslands may also be important feeding areas for wintering waterbirds.

The target for the attribute fringing habitats is: Maintain marginal fringing habitats that support turlough vegetation, invertebrate, mammal and/or bird populations.

4.13 Vegetation structure: turlough woodland

The natural climax vegetation for at least the upper margins of turloughs is wet-woodland. Goodwillie (2003) notes "Without grazing, a 'wet' turlough would have a central area of wetland vegetation made up of aquatic or amphibious plants that could start development when still water-covered, and be surrounded by small trees and shrubs, especially willows." "A 'dry' turlough would be totally covered by trees though the trees in the centre would be relatively small because of periodic kills caused by spring or summer flooding." Owing to traditional grazing of turloughs, turlough woodland is now quite rare. Some turloughs, however, notably those in the Coole-Garryland complex, have areas of mature, native woodland that floods most years. Perrin *et al.* (2008) identified a variant of their *Alnus glutinosa – Filipendula ulmaria* group, *Crataegus monogyna – Geranium robertianum* woodland (3 d) from the upper margins of turlough basins. They described this as a very rare type of stand of low scrub woodland dominated by *Crataegus monogyna* and *Rhamnus cathartica* (Perrin *et al.*, 2008). The full distribution of this turlough woodland variant is not known and it may yet be found within the Galway Bay Complex SAC. This, and possibly other not yet described turlough woodland sub-types, are important elements of the natural variation of turloughs in Ireland.

The target for the attribute vegetation structure, woodland structure is: Maintain appropriate turlough woodland diversity and structure.

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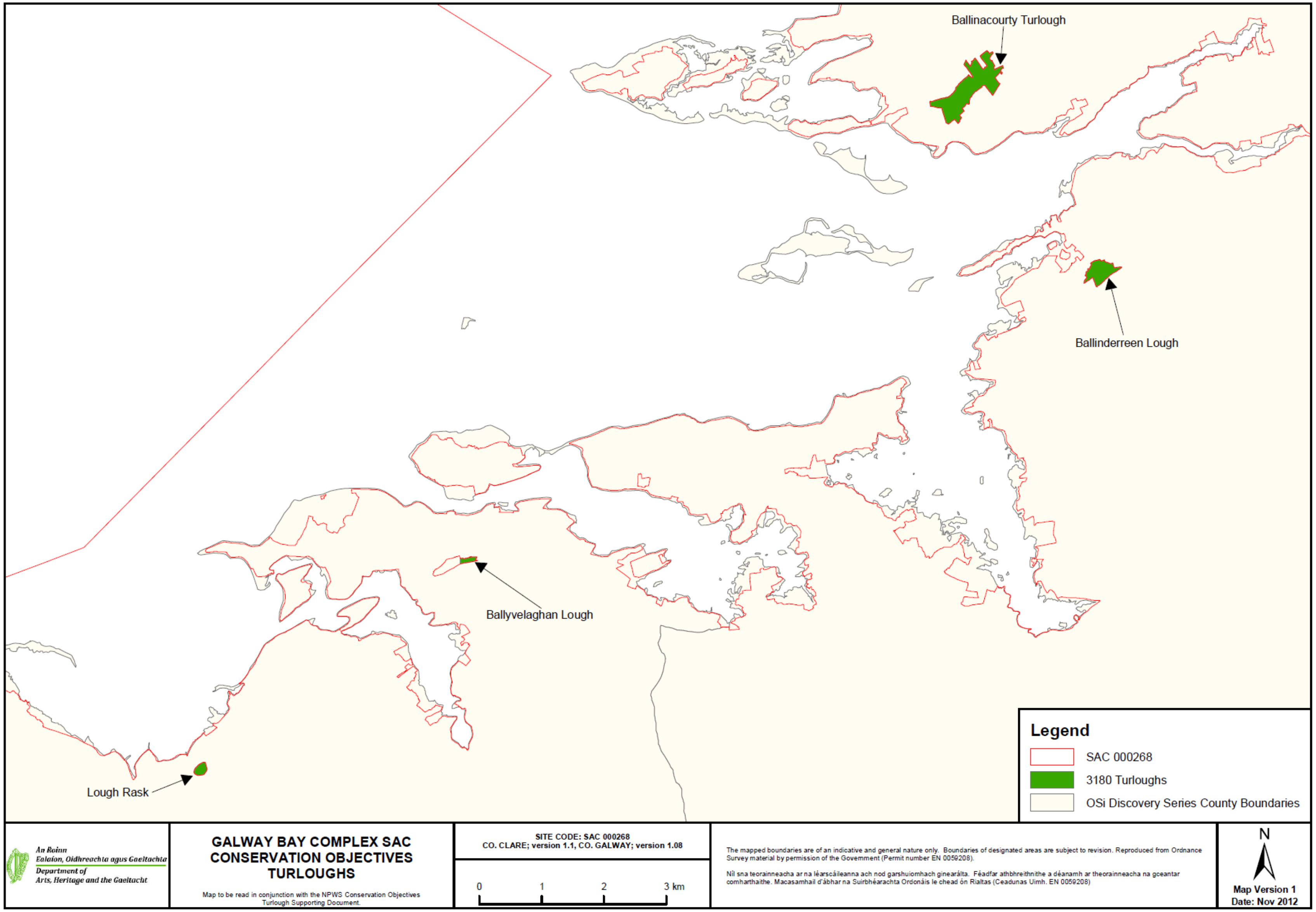
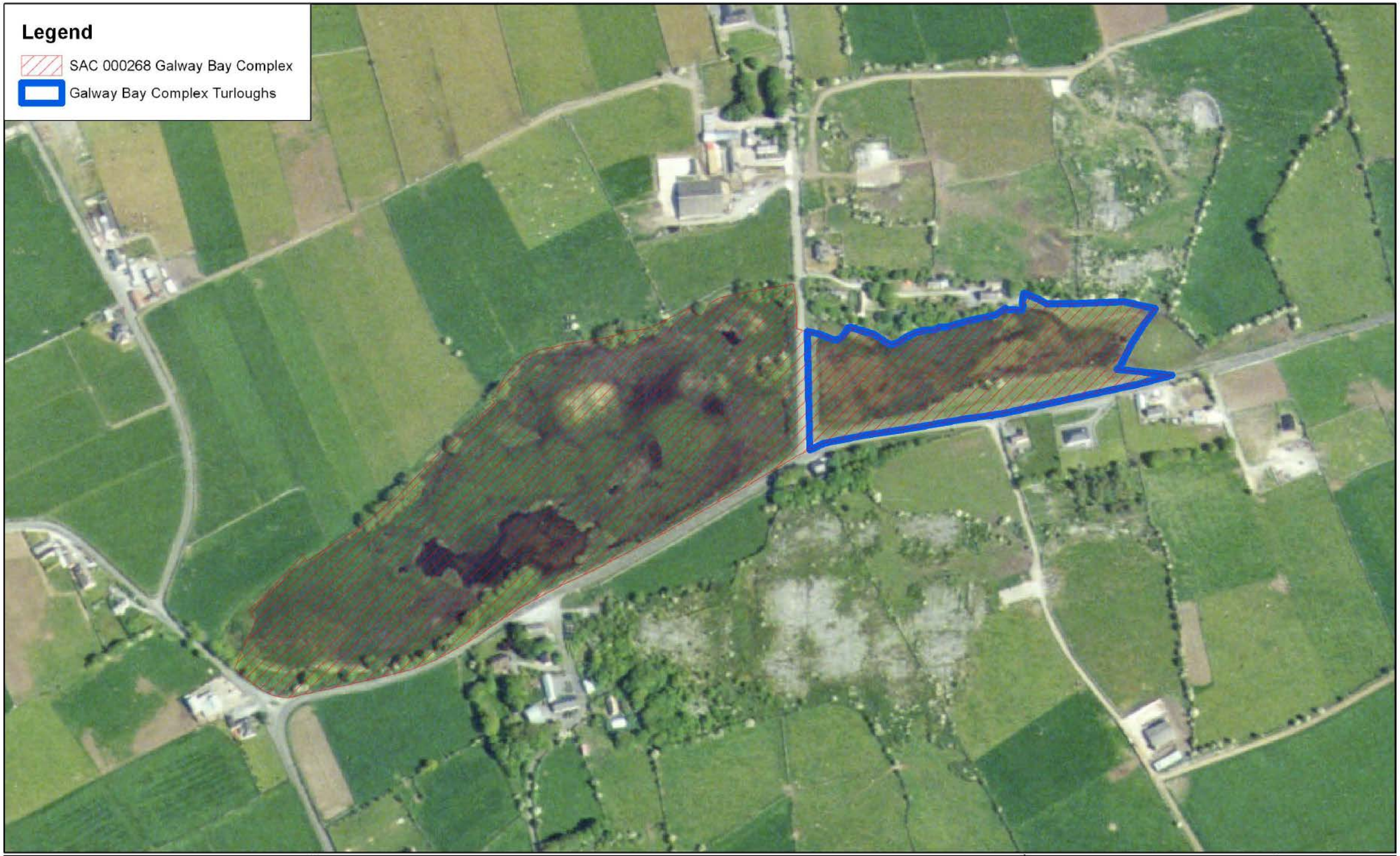
Appendix 1 Turlough distribution map



Appendix 2 Maps of individual turloughs



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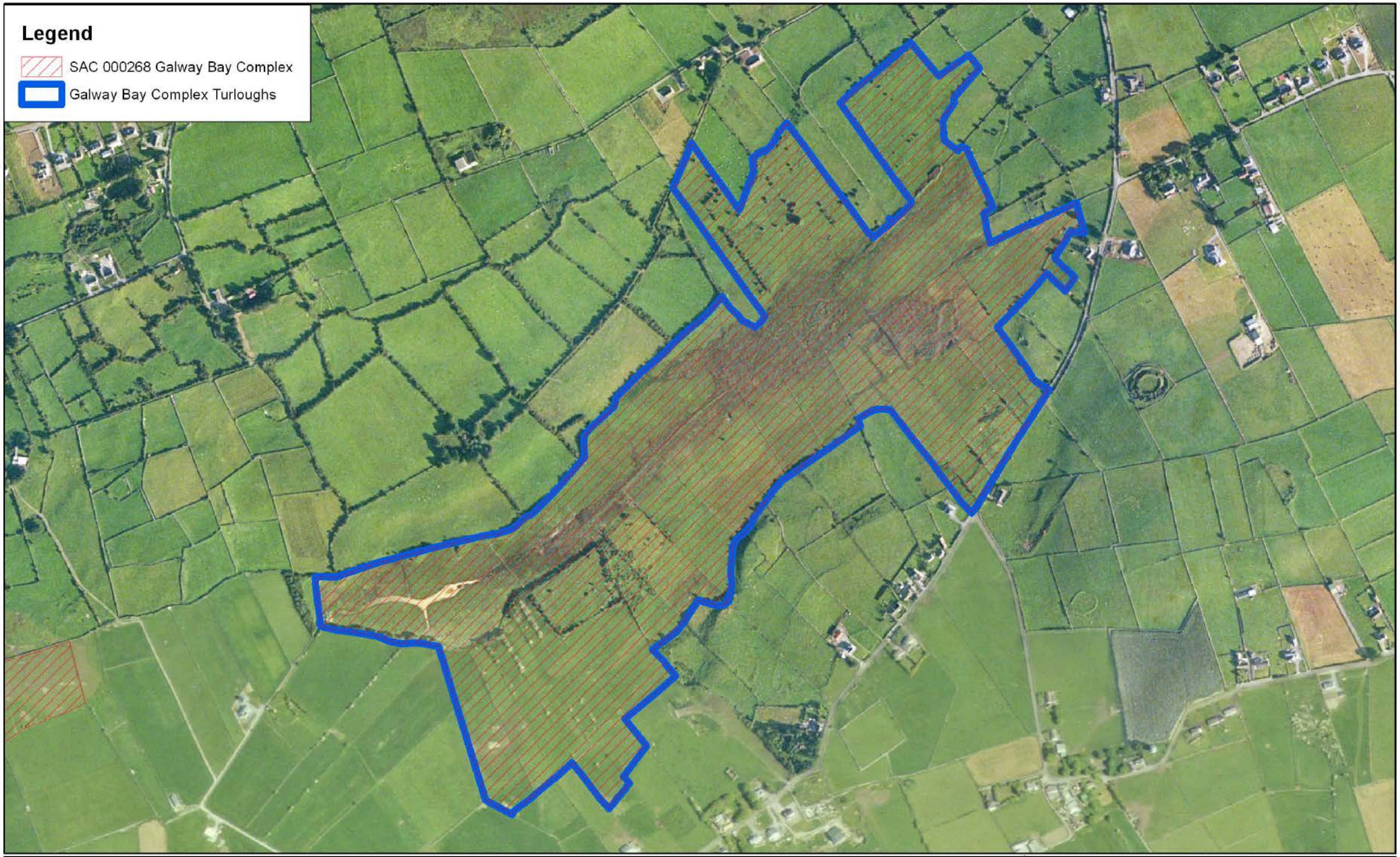

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