

NPWS

Lough Lurdeen Bog/Glenamaddy
Turlough SAC
(site code 301)

**Conservation objectives supporting document-
Turloughs and Rivers with muddy banks with
Chenopodium rubri p.p. and *Bidention* p.p.
vegetation**

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Contents

Contents.....	1
1. Introduction	3
1.1 Turloughs.....	3
1.2 Rivers with muddy banks with <i>Chenopodium rubri</i> p.p. and <i>Bidention</i> p.p. vegetation.....	3
1.3 Lough Lurgeen Bog/Glenamaddy Turlough SAC.....	4
1.4 Conservation objectives	4
2. Area.....	5
3. Range	5
4. Structure and functions	5
4.1 Hydrological regime	5
4.1.1 Hydrological regime: groundwater contribution	6
4.1.2 Hydrological regime: flood duration	6
4.1.3 Hydrological regime: flood frequency.....	7
4.1.4 Hydrological regime: flood area	7
4.1.5 Hydrological regime: flood depth	8
4.1.6 Hydrological regime: permanently flooded/wet areas.....	8
4.2 Soil type.....	8
4.3 Soil nutrient status.....	9
4.4 Physical structure: Bare ground	9
4.5 Chemical processes: Calcium carbonate deposition.....	10
4.6 Water quality.....	10
4.6.1 Water quality: nutrients	11
4.6.2 Water quality: colour	11
4.6.3 Water quality: phytoplankton biomass.....	12
4.6.4 Water quality: epiphyton biomass.....	12
4.7 Active peat formation	13
4.8 Vegetation composition: vegetation communities	13
4.9 Vegetation composition: vegetation zonation	14
4.10 Vegetation structure: sward height.....	15

4.11 Typical species	15
4.11.1 Typical species: terrestrial, wetland and aquatic plants	15
4.11.2 Typical species: aquatic invertebrates	17
4.11.3 Typical species: other invertebrates	18
4.11.4 Typical species: birds.....	19
4.12 Fringing habitats	21
4.13 Vegetation structure: turlough woodland	21
5. References	22
Appendix 1 Map of Glenamaddy Turlough.....	29
Appendix 2 Orthophotograph of Glenamaddy Turlough	30

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, 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, 2013).

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, 2013).

1.2 Rivers with muddy banks with *Chenopodium rubri* p.p. and *Bidention* p.p. vegetation

“Rivers with muddy banks with *Chenopodium rubri* p.p. and *Bidention* p.p. vegetation” (habitat code 3270) is a habitat in Annex I of the Habitats Directive. In Ireland, it is mainly found within turloughs that have areas from which the flood water recedes late and are prone to summer flooding. In the rest of Europe, the habitat is found on muddy banks of rivers in late-receding river floodplains (CEC, 2013). The Gearagh is the only known Irish example of “Rivers with muddy banks with *Chenopodium rubri* p.p. and *Bidention* p.p. vegetation” occurring in the floodplain of a ‘surface’ river. The occurrence of the habitat in some turloughs is perhaps unsurprising when they are considered as the floodplains of underground rivers.

Rivers with muddy banks with *Chenopodium rubri* p.p. and *Bidention* p.p. vegetation is a dynamic habitat found on damp, fine, mineral soils (typically alluvial muds). Typical species are small, short-lived, fast-growing annuals that are poor competitors. Colonisation of the habitat by perennial species is prevented by its exposure late in the growing season for a short period. The persistence of the habitat is dependent on a continuous supply of fine sediment.

Rivers with muddy banks with *Chenopodium rubri* p.p. and *Bidention* p.p. vegetation forms a vegetation community within the turlough habitat and can, therefore, be considered as a sub-set of the turlough vegetation.

In Ireland, habitat 3270 is considered to be in poor/inadequate conservation status as a result of nutrient enrichment, inappropriate grazing and drainage pressures (NPWS, 2007, 2008, 2013).

1.3 Lough Lurteen Bog/Glenamaddy Turlough SAC

Lough Lurteen Bog/Glenamaddy Turlough SAC comprises a large turlough and an expanse of raised bog near Glenamaddy in north-east Co. Galway. There is a small lake (Lough Lurteen) on the bog that is linked to the turlough by an out-flowing river. The close hydrological linkages between the raised bog, lake and turlough are considered to have resulted in a unique ecosystem of high conservation value. The SAC is selected for five habitats listed on Annex I of the EU Habitats Directive, two of which are priority habitats (turloughs* and active raised bogs*).

Glenamaddy Turlough has an area of over 170 ha in extent, at the north-west of the SAC. Three rivers flow into the turlough, the largest from Lough Lurteen, and a well-defined swallow hole occurs in the north-west corner. The turlough is relatively deep with a flattish floor that is uncovered for a short time, if at all (Goodwillie, 1992). It is in this area that habitat 3270, Rivers with muddy banks with *Chenopodium rubri* p.p. and *Bidention* p.p. vegetation, occurs. Glenamaddy turlough was site 55 in Coxon (1986, 1987 a and b) and number 20 in Goodwillie (1992). It is an important turlough for rare and threatened plant species and wintering waterbirds.

1.4 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.

Grazing is integral to the ecology of turloughs and it is important that appropriate grazing levels are maintained. Over-grazing and, in particular, under-grazing 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 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.

Little if any grazing is required for habitat 3270 Rivers with muddy banks with *Chenopodium rubri* p.p. and *Bidention* p.p. vegetation. It is important that this high conservation value habitat, dominated by rare species, is not confused with the wet annual community of common, 'weedy' species found on damp tracks and trampled/poached mineral soil. Natural disturbance by flooding and sediment deposition is the main ecological driver of habitat 3270.

Attributes and targets may change/become more refined as further information becomes available.

2. Area

Goodwillie (1992) measured the area of Glenamaddy turlough at 177.5 ha. The area covered by the turlough as mapped in the conservation objective is 172 ha. This map was created by digitising the outer boundary of the Goodwillie (1992) vegetation units. Within this, habitat 3270, Rivers with muddy banks with *Chenopodium rubri* p.p. and *Bidention* p.p. vegetation, covered an estimated 1.7 ha (Vegetation unit 8B, 'Wet Annuals') (Goodwillie, 1992). By contrast, Conaghan *et al.* (2006) recorded the bare muddy area with *Callitriche palustris* as exceeding 25 ha. The area of habitat 3270, unlike that of the turlough as a whole, is expected to vary, naturally, inter-annually, with flooding regime. The timing of observations will also significantly influence measurement of the area of habitat 3270.

The **target** for habitat area for turloughs* and Rivers with muddy banks with *Chenopodium rubri* p.p. and *Bidention* p.p. vegetation is: stable or increasing, subject to natural processes.

3. Range

The distribution of turloughs and known distribution of Rivers with muddy banks with *Chenopodium rubri* p.p. and *Bidention* p.p. vegetation in Lough Lurgen Bog/Glenamaddy Turlough SAC is shown in Appendices 1 and 2.

The **target** for the habitat distribution attribute for turloughs* and Rivers with muddy banks with *Chenopodium rubri* p.p. and *Bidention* p.p. vegetation 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 and Rivers with muddy banks with *Chenopodium rubri* p.p. and *Bidention* p.p. vegetation these include attributes such as hydrology, soils and various water quality attributes.

4.1 Hydrological regime

Hydrology is the key driver of turlough and Rivers with muddy banks with *Chenopodium rubri* p.p. and *Bidention* p.p. vegetation ecology. The different turlough communities, assemblages and species are affected by various hydrological attributes. The most important of these are described below.

Rivers with muddy banks with *Chenopodium rubri* p.p. and *Bidention* p.p. vegetation is flooded for an extended period of time each year, becoming exposed late in summer. Most turloughs with this habitat (3270) are fed by streams or underground conduits and these may supply fine sediment. Wave action may also be important in maintaining bare mud through erosion, re-suspension and deposition of sediment within the basin. The soils of habitat 3270 usually remain saturated for a significant period of time after becoming exposed, through a combination of local water table level and the water retention capacity/permeability of the soils (NPWS, 2013).

Goodwillie (1992), noted that three rivers flow into Glenamaddy turlough, the largest coming from Lough Lurgeen on the raised bog to the south-west. He said the main swallow hole is in the north-west ('Pollnadeirce') (Goodwillie, 1992). Swallow holes ('Pollanargid', marked on the GSI karst database as an enclosed depression) to the north-west of the turlough are above the elevation of the turlough, but may act as a spring supply to the turlough. Goodwillie (1992) also found that the floodwaters persisted late in the summer so that the turlough could not be surveyed in June or July, and noted that the base of the turlough is uncovered only for a short period, if at all. Wave erosion was evident, particularly on the south- and west-facing shorelines (Goodwillie, 1992).

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. Groundwater is likely to enter Glenamaddy turlough through the swallow holes, such as Pollnadeirce and Pollanargid. At Glenamaddy, there also appears to be a significant surface water contribution of base-poor water from areas of raised bog. Goodwillie (1992) said that the "incoming water seems to have little dissolved lime". It may be that the water observed by Goodwillie was predominantly surface water arising from peatland areas, or that the in-flowing groundwater is relatively mineral-poor. It is uncertain to what extent the natural groundwater : surface-water ratio has been altered by damage to the peatland.

The **target** for the attribute hydrological regime, groundwater contribution for turloughs* and Rivers with muddy banks with *Chenopodium rubri* p.p. and *Bidention* p.p. vegetation 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 for 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). It should also be possible to use plant species as indicators of the extent and duration of flooding in turloughs (see Goodwillie, 1992; Goodwillie *et al.*, 1997; Waldren, 2015). Consequently, both hydrological and vegetation indicators should be considered when measuring this attribute.

As noted above, the habitat Rivers with muddy banks with *Chenopodium rubri* p.p. and *Bidention* p.p. vegetation, is flooded for an extended period each year, becoming exposed in summer, and this allows the annual, short-lived species that typify the habitat to grow, while preventing perennial species from completing their lifecycles. Data for habitat 3270 at Coole indicates it is continuously flooded for around 250 days/year (Owen Naughton pers. comm.).

Goodwillie (1992) found that the floodwaters persisted at Glenamaddy late in the summer so that the turlough could not be surveyed in June or July, and noted that the base of the turlough is uncovered only for a short period, if at all. Conaghan et al. (2006) surveyed Glenamaddy on 28th August and found extensive mud indicating the floodwater did not fully recede until July or August. It is likely that that in some years, a significant area of Glenamaddy turlough remains permanently flooded.

The **target** for the attribute hydrological regime, flood duration for turloughs* and Rivers with muddy banks with *Chenopodium rubri* p.p. and *Bidention* p.p. vegetation 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 habitat Rivers with muddy banks with *Chenopodium rubri* p.p. and *Bidention* p.p. vegetation must flood at least once per year, however it is likely that a second, summer flood is required at lower frequency (perhaps once every five years) in order to exclude perennials (NPWS, 2013). Alternatively, persistent, year-round flooding every few years could prevent the establishment of perennials.

As noted above, Goodwillie (1992) observed that the flattish floor of Glenamaddy turlough is uncovered for a short period only, if at all, suggesting that a single flood event per year, that may sometimes persist throughout the summer, is typical for the site.

The **target** for the attribute hydrological regime, flood frequency for turloughs* and Rivers with muddy banks with *Chenopodium rubri* p.p. and *Bidention* p.p. vegetation 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 (including the area of Rivers with muddy banks with *Chenopodium rubri* p.p. and *Bidention* p.p. vegetation). 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 for turloughs* and Rivers with muddy banks with *Chenopodium rubri* p.p. and *Bidention* p.p. vegetation 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.) and basin morphology. The depth (and area/duration) 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.

As the habitat Rivers with muddy banks with *Chenopodium rubri* p.p. and *Bidention* p.p. vegetation generally occurs at the base of the turlough, it is associated with the maximum flood depth. It is also generally found in relatively deep turloughs. The depth of water level fluctuations (likely to be from 2 m up to 6 m plus) and average water depth during flooding may be significant factors in limiting the colonisation of habitat 3270 by perennial species (NPWS, 2013).

Goodwillie (1992) observed that Glenamaddy turlough “is quite a deep one” and this, combined with the “flattish floor” and long flood duration, contributes to the natural occurrence of habitat 3270 at the site.

The **target** for the attribute hydrological regime, flood depth for turloughs* and Rivers with muddy banks with *Chenopodium rubri* p.p. and *Bidention* p.p. vegetation 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. At Glenamaddy, habitat 3270 is associated with extensive areas of wet mud, there are shallow peat deposits along the margins, particularly at the south-east and south, adjacent to the raised bogs and there is an extensive area of marl pond vegetation (9C) to the south-west (Goodwillie, 1992).

The **target** for the attribute hydrological regime, permanently flooded/wet areas for turloughs* and Rivers with muddy banks with *Chenopodium rubri* p.p. and *Bidention* p.p. vegetation 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, 1987b; Goodwillie, 1992; Kimberley, 2008; Waldren, 2015). 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).

Rivers with muddy banks with *Chenopodium rubri* p.p. and *Bidention* p.p. vegetation is found on damp, fine, mineral soils (typically alluvial muds). When floodwaters recede, relatively fertile, bare mud is exposed and rapidly colonised (NPWS, 2013). The on-going development of the habitat depends on a continuous supply of fine sediment, which may be derived from an external source and delivered through groundwater or surface water, or an internal supply resulting from natural sediment dynamics within the turlough. The soils of habitat 3270 usually remain saturated for a significant period of time after exposure, allowing the characteristic species to become established, but can dry out showing superficial cracking in late summer/autumn. Moisture is retained in the soils through a combination of local water table level and the water retention capacity/permeability of the soils.

Goodwillie (1992) noted bare sand with stones and shallow peat along the upper margins of Glenamaddy. He also recorded an area of marl pond and peat at the lower levels in the south-western corner of the turlough and cited Coxon (1986) as having recorded 80 cm grey-brown silty clay over 10 cm marl in a section of the lower basin.

The **target** for the attribute soil type for turloughs* and Rivers with muddy banks with *Chenopodium rubri* p.p. and *Bidention* p.p. vegetation is: Maintain 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). Maintenance of the natural nutrient status is important, as increases in soil nutrient status can significantly alter the vegetation communities and impact on sensitive aquatic assemblages.

Rivers with muddy banks with *Chenopodium rubri* p.p. and *Bidention* p.p. vegetation appears to be associated with relatively fertile soils (relative to other turlough communities).

The soil nutrient status at Glenamaddy turlough may be artificially elevated owing to the long-term discharge of sewerage from Glenamaddy village to the turlough.

The **target** for the attribute soil nutrient status for turloughs* and Rivers with muddy banks with *Chenopodium rubri* p.p. and *Bidention* p.p. vegetation is: Maintain/restore 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

Chenopodium 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). At Glenamaddy the bare ground that allows habitat 3270 to occur results from the naturally long flood duration.

The **target** for the attribute Physical structure, bare ground for turloughs* and Rivers with muddy banks with *Chenopodium rubri* p.p. and *Bidention* p.p. vegetation is: Maintain sufficient wet bare ground, as appropriate.

4.5 Chemical processes: Calcium carbonate deposition

Calcium carbonate (CaCO₃) deposition is a feature of very many turloughs (Coxon, 1994; Goodwillie, 2003). Base-rich mineral soils appear to be typical of Rivers with muddy banks with *Chenopodium rubri* p.p. and *Bidention* p.p. vegetation, and precipitation of CaCO₃ from the water column may be an important contributor. Both physical and biological processes clearly play a part in precipitating CaCO₃ 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 CaCO₃ precipitation, it could be affected by drainage activities in the turlough or the zone of contribution (groundwater catchment) impacting the CaCO₃ concentration in the floodwater, or by changes to biological communities, impacting the precipitation processes. As noted above, Goodwillie (1992) noted that the water in Glenamaddy turlough appeared to have little dissolved lime. It appears that the turlough receives base-poor water from the inflowing streams (particularly those draining peat), however the inflowing groundwater is likely to be base-rich. Coxon (1986) recorded historically deposited marl below 80 cm of silty clay, however the 'Marl Pond' recorded by Goodwillie (1992) suggests there is more recent or on-going calcium carbonate deposition.

The **target** for the attribute chemical processes, Calcium carbonate deposition for turloughs* and Rivers with muddy banks with *Chenopodium rubri* p.p. and *Bidention* p.p. vegetation is: Maintain CaCO₃ 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. Glenamaddy turlough, however, has been the point of discharge for the sewerage from Glenamaddy village since the 1950s. The discharge point is at the swallow hole Pollnadeirce, and it is likely that the receiving environment for the waste water varies over time, with the flood cycle. If the turlough is flooded or water is discharging from Pollnadeirce, the turlough will be the receiving environment. When the turlough is dry, or water is discharging from the turlough to the swallow hole, the groundwater is the receiving environment. The waste water receives minimal treatment before discharge. The impacts of the discharge on the ecology of Glenmaddy turlough are uncertain as there has been limited ecological survey of the site and there are no baseline, pre-discharge data.

Turlough 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 used for the turlough water, depending on the site's fertility and sensitivity to phosphorus enrichment. A threshold of $\leq 10\mu\text{g/l}$ TP was set for the least fertile ('extremely sensitive') turloughs as defined by the vegetation communities, and a threshold of $\leq 20\mu\text{g/l}$ 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 $\leq 10\mu\text{g/l}$ a lake is oligotrophic and >10 to $\leq 20\mu\text{g/l}$ mesotrophic (McGarrigle *et al.*, 2002, Appendix I).

Work undertaken by TCD 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; NPWS, 2013; Waldren 2015). The TCD team considered that the natural background levels for all turloughs were likely to be $<10\mu\text{g/l}$ (Norman Allott and Catherine Coxon, pers. comm.). Waldren (2015) concluded that $<10\mu\text{g/l}$ TP indicates 'Very good' quality, $10\text{--}20\mu\text{g/l}$ TP indicates 'Good' quality, $20\text{--}50\mu\text{g/l}$ TP 'Intermediate' quality, and $>50\mu\text{g/l}$ P indicates 'Bad' quality.

While it may ultimately be necessary to set site-specific TP targets for turloughs, a target of $\leq 10\mu\text{g/l}$ TP is used here for more oligotrophic sites dominated by fen and other sedge-rich vegetation of low-fertility and high species diversity, and a target of $\leq 20\mu\text{g/l}$ TP for less oligotrophic sites and there should be no deterioration in mean TP values.

The Working Group on Groundwater (2005) categorised Glenamaddy turlough as naturally highly sensitive to nutrient enrichment, and considered that it is likely to have been significantly impacted by enrichment owing to the waste water discharge. Based on this assessment, the appropriate target for Glenamaddy turlough is $\leq 20\mu\text{g/l}$ TP, however this should be confirmed through investigation of the phosphorus concentration of the inflowing ground- and surface-waters (i.e. pre-mixing with the waste water discharge). Where the average annual TP concentration is $\leq 10\mu\text{g/l}$ TP, there should be no deterioration, i.e. the target should be revised to $\leq 10\mu\text{g/l}$ TP.

The **target** for the attribute water quality, nutrients for turloughs* and Rivers with muddy banks with *Chenopodium rubri* p.p. and *Bidention* p.p. vegetation is: Maintain/restore average annual TP concentration of $\leq 10\mu\text{g/l}$ TP, or $\leq 20\mu\text{g/l}$ TP, as appropriate.

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; Waldren, 2015). Drainage of surrounding raised bog may have artificially increased water colour at Glenamaddy turlough.

The **target** for the attribute water quality, colour for turloughs* and Rivers with muddy banks with *Chenopodium rubri* p.p. and *Bidention* p.p. vegetation is: Maintain/restore 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. Waldren (2015) used maximum recorded Chlorophyll *a* > 10 $\mu\text{g/l}$ as a negative indicator for conservation condition in turloughs. 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 values¹”, which includes a turlough’s ‘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 for turloughs* and Rivers with muddy banks with *Chenopodium rubri* p.p. and *Bidention* p.p. vegetation is: Maintain/restore appropriate chlorophyll *a* concentrations (annual mean <2.5 or <8 $\mu\text{g/l}$, annual maximum values ≤ 8 and <25 $\mu\text{g/l}$, as appropriate).

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. $\geq 20\mu\text{g/l}$) (Norman Allott, pers. comm.). The filamentous forms recorded include *Oedogonium*, *Spirogyra* and *Mougeotia* species (Norman Allott, pers. comm.). A few turloughs with high TP did not develop extensive algal mats, at least partly because of high water colour (Norman Allott, pers. comm.). Waldren (2015) used the ‘Presence of filamentous algal mats covering at least 2% of turlough area on at least one occasion over three years of observation’ as a negative indicator for turlough conservation condition

¹ a minimum of four samples is required, distributed throughout the growing season.

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 for turloughs* and Rivers with muddy banks with *Chenopodium rubri* p.p. and *Bidention* p.p. vegetation 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). Active peat formation is not a feature of habitat 3270, and Rivers with muddy banks with *Chenopodium rubri* p.p. and *Bidention* p.p. vegetation.

Shallow peat deposits are found along the margins of Glenamaddy turlough, particularly at the south-east and south, adjacent to the raised bogs peat (Goodwillie, 1992). Peat is also found at the base of the turlough along the south-western limb (Goodwillie, 1992).

The **target** for the attribute active peat formation for turloughs* is: Maintain 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; Waldren, 2015). 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). Waldren (2015) developed positive and negative indicator communities for turloughs. The characteristic turlough communities identified as positive indicators (turlough-type dependent) included the *Eleocharis acicularis* community, *Carex fen* (*Molinia caerulea*-*Carex panicea* community), *Schoenus nigricans* fen and flooded woodland and pavement communities (Waldren, 2015).

The vegetation community of Rivers with muddy banks with *Chenopodium rubri* p.p. and *Bidention* p.p. vegetation is composed of small, short-lived, fast-growing annuals that are poor competitors and includes a number of rare species (see typical species, Section 4.11). Goodwillie (1992) describes the community in his 'Wet annual' vegetation unit (8B). In conducting the conservation assessment, Goodwillie (2007) examined the phytosociological context of the habitat and concluded the

following: “Schaminée *et al* 1998 divide the *Bidention tripartitae* in the Netherlands into the *Polygono-Bidentetum* (3-110 days of inundation), the *Chenopodietum rubri* (50-250 days) and the *Eleocharito acicularis – Limoselletum* (130-300). This system has definite parallels in Ireland. All three communities may be recognized in turloughs and at the Gearagh . . .”.

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.

The vegetation of Glenamaddy turlough is described in Goodwillie (1992). The base of the turlough is dominated by the *Polygonum amphibium* community (8A) (48.6 ha). Above this is the wet *Carex nigra* community (6B) (78.4 ha) (Goodwillie, 1992). Peat grassland (2D) also covers a large area of Glenamaddy (27.9 ha). The other communities recorded were Poor grassland (2B) (2.2 ha), Tall herb (3A) (3.0 ha), species rich *Potentilla reptans* (4B) (2.6 ha), *Schoenus* fen (4D) (4.2 ha), Dry *Carex nigra* (6A) (1.8 ha), Peaty *Carex nigra* (6D) (1.7 ha) and Marl Pond (9C) (4.7 ha) (Goodwillie, 1992). Goodwillie (1992) commented that “For such a large area the vegetation of this turlough is amazingly homogenous”. Habitat 3270 Rivers with muddy banks with *Chenopodium rubri* p.p. and *Bidention* p.p. vegetation, was represented by the Wet annual (8B) community and estimated to cover 1.7 ha (Goodwillie, 1992). However, Conaghan *et al.* (2006) estimated that the community, which was composed of *Callitriche palustris*, *Chenopodium rubrum*, *Gnaphalium uliginosum* and *Persicaria maculosa*, covered more than 25 ha in August 2006.

The **target** for the attribute vegetation composition, vegetation communities for turloughs* and Rivers with muddy banks with *Chenopodium rubri* p.p. and *Bidention* p.p. vegetation 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.

Goodwillie (1992) maps and describes the vegetation zonation at Glenamaddy.

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".

As noted above little if any grazing is required for habitat 3270 Rivers with muddy banks with *Chenopodium rubri* p.p. and *Bidention* p.p. vegetation. Natural disturbance by flooding and sediment deposition is the main ecological driver of habitat 3270 and it should not be confused with the wet annual community of common, 'weedy' species found on damp tracks and trampled/poached mineral soil.

The **target** for the attribute vegetation structure, sward height for turloughs* is: Maintain sward heights appropriate to the vegetation unit, and a variety of sward heights across the 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 1 lists the typical turlough plant species (NPWS, 2013). 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; Waldren, 2015). Table 2 lists other more widespread vascular plant species that are commonly encountered in turloughs, often at high cover abundance.

The TCD integrated turlough project 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.; Waldren, 2015).

The plant list in Table 1 includes species typical of the Annex I habitat Rivers with muddy banks with *Chenopodium rubri* p.p. and *Bidention* p.p. vegetation (3270) (NPWS, 2013). Other species associated with habitat 3270 include *Atriplex prostrata*, *Gnaphalium uliginosum*, *Rorippa palustris*, *Persicaria hydropiper*, *Chenopodium rubrum*, *Juncus bufonius* and, *Bidens tripartita*. At Glenamaddy, *Callitriche palustris*, *Chenopodium rubrum*, *Gnaphalium uliginosum* and *Persicaria maculosa* are found in habitat 3270, with abundant *Viola persicifolia* forming a distinct zone above (Conaghan *et al.*, 2006).

Table 1 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 is given, where relevant, as a superscript (bryophytes only).

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

Table 2 Widespread plant species commonly found in turloughs, frequently at high abundance. Species indicative of oligotrophic conditions are given a ‡.

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

Waldren (2015) said “many of the characteristic plant species encountered in turloughs also occur in other wetlands, or indeed in well-drained calcareous habitats; what is unique about turlough vegetation is the juxtaposition of ecologically different species along short but strong ecological

gradients.” Rather than recommending a revised list of typical species, the authors identified plant indicator species that are indicators for flood duration and nutrient status (Waldren, 2015).

Lockhart *et al.* (2012) 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.*, 2012).

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

Glenamaddy turlough has a number of rare and/or threatened species including *Callitriche palustris*, *Viola persicifolia*, *Chenopodium rubrum* and the near threatened (NT) bryophyte *Drepanocladus sendtneri*, with most of these species associated with habitat 3270 (Goodwillie, 1992; Conaghan *et al.*, 2006; Lockhart *et al.*, 2012).

The **target** for the attribute typical species, terrestrial, wetland and aquatic plants communities for turloughs* and Rivers with muddy banks with *Chenopodium rubri* p.p. and *Bidention* p.p. vegetation is: Maintain typical species within and across sites

4.11.2 Typical species: aquatic invertebrates

NPWS (2013) provided an updated list of typical aquatic invertebrate species of turloughs (see Table 3), and the available information on this group is reviewed by Sheehy Skeffington *et al.* (2006) and Reynolds (2016). The species of greatest conservation importance in turloughs include the rare chydorid, *Eurycerus 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* (nt), *Graptodytes bilineatus* (nt), *Berosus signaticollis* (EN) and *Dryops similis* (nt) (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: *Haliphus 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 (CR) 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). *Siphonurus armatus* is a critically endangered (CR) 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.).

Table 3 Typical aquatic invertebrate species of turloughs. 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.

<p>Aquatic invertebrates:</p> <p>Platyhelminthes, Turbellaria: <i>Polycelis nigra</i>; Crustacea, Cladocera: <i>Alonella excisa</i>, <i>Alona rustica</i>, <i>Alonopsis elongate</i>, <i>Alona affinis</i>, <i>Eurycercus glacialis</i>*, Crustacea, Copepoda: <i>Diaptomus castor</i>; Insecta, Odonata: <i>Lestes dryas</i>*, <i>Sympetrum sanguineum</i>; Insecta, Coleoptera: <i>Agabus labiatus</i>*^{NT}, <i>Agabus nebulosus</i>, <i>Bagous limosus</i>^{CR}, <i>Berosus signaticollis</i>*^{EN}, <i>Dryops similis</i>*^{NT}, <i>Graptodytes bilineatus</i>*^{NT}, <i>Haliplus obliquus</i>, <i>Haliplus variegates</i>^{VU}, <i>Helophorus minutus</i>, <i>Helophorus nanus</i>^{VU}, <i>Hygrotus impressopunctatus</i>, <i>Laccobius colon</i>, <i>Laccobius minutus</i>, <i>Ochthebius minimus</i>, <i>Rhantus frontalis</i>.</p>
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No specific linkages have yet been made between aquatic invertebrates and habitat 3270, Rivers with muddy banks with *Chenopodium rubri* p.p. and *Bidention* p.p. vegetation.

Survey of water beetles at Glenamaddy has not yielded rare or typical turlough species.

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

4.11.3 Typical species: other invertebrates

NPWS (2007, 2013) provides a list of typical terrestrial invertebrate species of turloughs (see Table 4). The EU Interpretation Manual (CEC, 2013) 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 4 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.).

Table 4 The typical terrestrial invertebrate species of turloughs (NPWS, 2007, 2013). Species indicated by * have a strong association with turloughs, i.e. most/all records for that species in Ireland are from turloughs.

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

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.

No specific linkages have yet been made between terrestrial invertebrates and habitat 3270, Rivers with muddy banks with *Chenopodium rubri* p.p. and *Bidention* p.p. vegetation, however it is likely to be used by terrestrial wetland invertebrates when dry.

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

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 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.

Table 5 IWeBS count data for Glenamaddy Turlough. Data courtesy of Dr Olivia Crowe, BirdWatch Ireland. Emboldened Mean values (2009/10 – 2013/14) indicate nationally important numbers (i.e. 1% or more of one species, subspecies or population of waterbirds occurring in Ireland)

Species	2001/02	2007/08	2008/09	2009/10	2010/11	2012/13	2013/14	Mean (2009/10-2013/14)	Peak (2009/10-2013/14)
Mute Swan	2	4	4	15	5		19	10	19
Whooper Swan	143	23	20	29	125	5	136	74	136
Greenland White-fronted Goose	70	110	90	75	60		110	61	110
Snow Goose							1	0	1
Wigeon	247	832	269	596	218	48	445	327	596
Teal	116	356	112	126	127	10	47	78	127
Mallard	80	118	86	152	197	28	90	117	197
Pintail							1	0	1
Shoveler		16	15	10	120		2	33	120
Pochard	16	31	2	2	32	6	5	11	32
Tufted Duck	12	20	85	80	14	75	32	50	80
Goldeneye	4	7	6	12	1		2	4	12
Smew			1	1				0	1
Great Northern Diver					1			0	1
Little Grebe		16	1	17	2			5	17
Great Crested Grebe	1	16	11	15		5	2	6	15
Cormorant			1	1				0	1
Little Egret			1					0	0
Grey Heron		1	2	2	1	1	1	1	2
Moorhen		4	1	3				1	3
Coot		70	18	39	5		2	12	39
Golden Plover	200	5,000	4,000	200	2,500		5,000	1,925	5,000
Lapwing	750	2,200	1,124	650	445		1,800	724	1,800
Dunlin		24		10	150			40	150
Ruff				4				1	4
Snipe		1	3	1		2		1	2
Black-tailed Godwit		3	15		1			0	1
Curlew	10	61	59	20	10	11	16	14	20
Redshank		1	5			4	5	2	5
Black-headed Gull	2	15	7	6	49	9	4	17	49
Herring Gull			1	2				1	2

NPWS internal files noted that Glenamaddy turlough is used by Greenland White-fronted Goose, part of the River Suck flock. Regular counts of non-breeding waterbirds at Glenamaddy Turlough (Subsite OG341) are undertaken as part of the Irish Wetland Bird Survey (I-WeBS). Table 5 sets out counts for a series of seven winter seasons, indicating on-going use by Greenland White-fronted Goose. Nationally important numbers of Shoveler and Golden Plover were recorded between winter

2009/10 and winter 2013/14 (Dr Olivia Crowe, pers. comm.). Large numbers of Lapwing occurred in some winters. It is likely that Golden Plover and Lapwing find a suitable roosting resource close to the turlough water's edge, and may also forage in the areas of the turlough that are not inundated with water.

The **target** for the attribute typical species, birds for turloughs* 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.

While the relationship between fringing habitats and habitat 3270, Rivers with muddy banks with *Chenopodium rubri* p.p. and *Bidention* p.p. vegetation, has not yet been established, it is likely that terrestrial invertebrates associated with habitat 3270 in late summer are reliant on fringing habitat for over-wintering.

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

Raised bog is an important and less common fringing habitat for some turloughs, such as Glenamaddy, in east Galway and Roscommon. The co-occurrence of and the maintenance/restoration of transitional vegetation between these two priority habitats is of high conservation value. Further investigation is required of the use of these habitats where they co-occur by invertebrate, bird and mammal species.

The **target** for the attribute fringing habitats for turloughs* and Rivers with muddy banks with *Chenopodium rubri* p.p. and *Bidention* p.p. vegetation 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). 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 for turloughs* is: Maintain appropriate turlough woodland diversity and structure.

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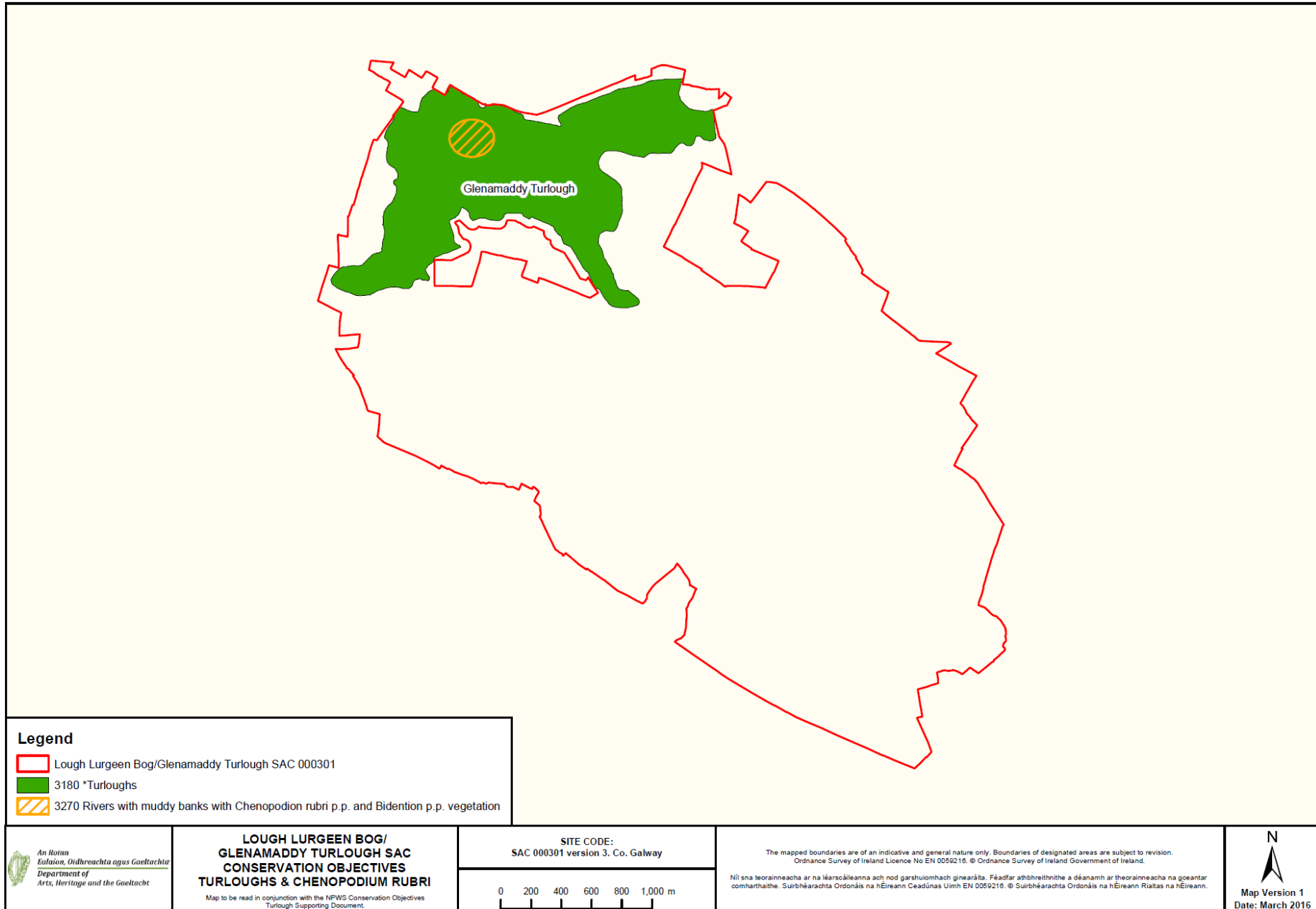
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Appendix 1 Map of Glenamaddy Turlough



Appendix 2 Orthophotograph of Glenamaddy Turlough

