

**SERIES OF ECOLOGICAL ASSESSMENTS
ON ARTERIAL DRAINAGE MAINTENANCE No 11**

**Ecological Impact Assessment (EcIA) of the Effects of
Statutory Arterial Drainage Maintenance Activities on
Fens, Mires & Whorl Snails**



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Foreword

This Ecological Impact Assessment follows on from the strategic approach outlined in “Series of Ecological Assessments on Arterial Drainage Maintenance No. 1: Screening of NATURA 2000 Sites for Impacts of Arterial Drainage Maintenance Operations”.

It examines the impacts of statutory arterial drainage maintenance activities on fens, mires and whorl snails, outlines measures to mitigate any negative impacts, and possible enhancement opportunities.

Environment Section

EXECUTIVE SUMMARY

The objective of this ecological impact assessment was to determine the likely effects of statutory arterial drainage maintenance activities on protected Annex I habitats fens and mires and protected Annex II whorl snail species in accordance with the requirements of the EU Habitats Directive. In Ireland there are twenty Special Areas of Conservation (SAC) sites designated for alkaline fens, *Cladium* fens, transition mires and whorl snails *Vertigo angustior*, *V. geyeri* and *V. moulinsiana* which overlap with Arterial Drainage Schemes channels on which works were carried out under the 1945 Arterial Drainage Act and the 1995 Amendment to that Act. Of this list of twenty SACs, ten representative sites were chosen for ecological site walkover surveys to assess the impact or potential impact of drainage maintenance works. An extended desk study of the all twenty sites, and the subject conservation interests, was also completed.

It was found that the scientific literature relating to the conservation status and requirements of fen habitat indicate that land drainage and drying of wetland habitats has a significant, detrimental impact on fen and mire habitat and on whorl snail species. It is considered that where drainage maintenance results in the ongoing, long-term drying out of surface water and groundwater dependant habitats that this would constitute a significant impact. Further scientific study is required to assess the drying out effect of ongoing drainage maintenance on wetland and fen habitats, particularly within the SACs.

The scope for future scientific study to be carried out by the OPW is as follows:

- To what spatial extent if any does arterial drainage maintenance dry out fen habitat and is this spatial area increasing with ongoing maintenance i.e. are larger and larger areas of SAC sites being dried out or is it confined to a corridor either side of drainage channels. Irrespective of this it is important to note that drying out of fen habitat is considered a significant negative impact, particularly with regard to *Cladium* fen (priority Annex I habitat).
- To what extent does fen habitat recover during the maintenance interval or has this area been permanently degraded. This must be assessed on a site by site basis in consultation with experts in NPWS and in utilising long term monitoring data interpreted by both hydro-geologists and ecologists.
- To what extent do the groundwater levels fluctuate within a fen/mire habitat based on the drainage maintenance intervals and what is the impact on the habitat from this activity.
- To what extent do drainage maintenance works affecting wetland and riparian habitats impact on whorl snails through the drying out of these habitats on which they depend. In addition, the direct impact of vegetation removal within channels containing protected whorl snail species requires further study to establish the significance of this potential impact.
- As ongoing works have the potential to impact on these conservation interests it is recommended that these further studies are carried out prior to works taking place in susceptible drainage channels. It is understood that this may not be possible, with the requirement for ongoing drainage maintenance; however, the potential for direct impacts on fen and whorl snails has been identified in this report. It is recommended that these potential impacts are addressed in consultation with the NPWS in order to ensure drainage maintenance operations are compliant with the requirements of the EC (Natural Habitats) Regulations 1997.

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1 INTRODUCTION

1.1 Project overview

The objective of this report is to carry out a study to determine the likely ecological effects of statutory arterial drainage maintenance activities on the following protected habitats: alkaline fens; calcareous fens with *Cladium mariscus* and species of the *Caricion davallianae*; and transition mires and quaking bogs. It is also the objective of this document to assess the potential impacts, of the statutory arterial drainage maintenance activities on three protected species of whorl snails, *Vertigo angustior*, *V. geyeri* and *V. moulinsiana*, all Annex II species, listed in the same Directive. This report has been prepared as part of the OPW's series of ecological assessments series.

A fen is a wetland with a permanently high water level at or just below the surface. Its principal source of nutrients is from surface or ground water and the substrate is an alkaline to slightly acid peat soil. Fens tend to occur in limestone regions, where their water supply is sufficiently rich in minerals. This study set out to establish the significance of impacts of drainage maintenance on an ongoing basis within the channels, and makes recommendations regarding what needs to be done to protect these internationally important habitats and species. Whorl snails favour damp or wet habitats, especially marshes, where they live mostly in moss, leaves and decaying vegetation. They are also associated with the fen habitats under examination in this report. Hydro-geological changes and loss of habitat are currently the main factors influencing the decline of these habitats and also in turn affecting the whorl snail species.

Drainage maintenance work involves maintenance of rivers and others channels which were modified by OPW in the past as part of an Arterial Drainage Scheme. The purpose of such maintenance works is to maintain channel conveyance at the 'design level' of the original scheme by removing the accumulations of silt, vegetation and other debris. Maintenance of such schemes is a statutory obligation of the OPW, as is compliance with the relevant nature conservation legislation. The drainage maintenance schemes in many cases need to balance flood risk management, agriculture and biodiversity. The NPWS site synopses for almost all aquatic and wetland designated sites in Ireland mention drainage as a key threat (Source: NPWS). It has been observed that the word 'drainage' and phrase 'drainage maintenance' are interchangeable among non-engineering persons and the misunderstanding of these terms among ecologists and NPWS staff may have led to confusion and under-reporting of impacts of the drainage maintenance activities assessed in this report.

The original drainage works would have involved hard engineering works, including widening and deepening of channels. Arterial drainage maintenance, in contrast, entails a much more moderate approach in construction activities where works are executed in line with the current OPW environmental work practices; ecological disturbance is minimised and habitat enhancement is common (OPW, 2007).

Scientific literature reviewing the environmental and ecological impacts of arterial drainage and drainage maintenance in Ireland to date has been generally limited to studies on the impacts to fisheries, specifically in relation to salmonids (McCarthy 1977; McCarthy 1983; Lynch & Murray 1992; O'Grady 1989; O'Grady *et al*, 1991; Kennedy *et al*, 2008; Toner *et al*, 1965). In an effort to address this shortfall in guidance the Environmental Section of OPW has, in consultation with National Parks and Wildlife Service (NPWS), the Central Fisheries Board (CFB), Regional Fisheries Boards (RFBs) and Birdwatch Ireland, recently prepared a report

entitled 'Screening of Natura 2000 Sites for Impacts of Arterial Drainage Maintenance Operations' (OPW, 2007). A subsequent series of ecological assessments for individual conservation interests is now being prepared, including the current assessment. The Screening Report sets out a strategic approach to managing the requirements of the EU Habitats Directive in relation to OPW drainage maintenance activities.

1.2 Legal framework

The European Council Directive No. 92/43/EEC was transposed into Irish law in S.I. 94/1997 European Communities (Natural Habitats) Regulations 1997. In accordance with Section 31 of these Regulations natural habitats of European interest listed on Annex I of the Regulations require legal protection and the designation of conservation sites, referred to as Special Areas of Conservation (SAC). Alkaline fens, calcareous fens with *Cladium mariscus* and species of the *Caricion davallianae* and transition mires and quaking bogs are all Annex I habitat types; while calcareous fens with *Cladium mariscus* and species of the *Caricion davallianae* is a priority habitat type i.e. habitat in danger of disappearance and whose natural range falls within the territory of the European Union.

Since 1997 The European Communities (Natural Habitats) Regulations, 1997 has been amended to provide a more comprehensive level of protection in 1998 and 2005. Additional protection was afforded to listed floral species under the Flora Protection Order, 1999 which in conjunction with the Wildlife Amendment Act, 2000 provides enhanced legal protection for species and habitats (NPWS website).



Plate 1 Askeaton Fen SAC.

In Ireland there are twenty SACs designated for the conservation interests of the current study which overlay Arterial Drainage Schemes channels on which works were carried out under the 1945 Arterial Drainage Act and 1995 Amendment to that Act. These sites have one or more of the conservation interests under assessment in this report. Of this list of twenty SACs, ten representative sites were chosen for ecological site walkover surveys to assess the impact or potential impact of drainage maintenance operations.

To ensure compliance with the EC Habitats Directive 1992 the OPW is required to carry out environmental assessments for European sites (Natura 2000 network) which overlap with drainage operations and drainage maintenance works. In accordance with Section 31 of the EC (Natural Habitats) Regulations (1997), where an operation or activity is carried out by the state that is likely to have a significant effect on a European site, an appropriate assessment should be carried out on the implications for that site in view of its conservation objectives.

OPW operations or activity shall only be undertaken when it is ascertained that these will not adversely affect the integrity of the site and then, having regard to conclusions from the

assessment (OPW, 2007). The objective of the current Ecological Impact Assessment is to determine the likely effects of statutory arterial drainage maintenance activities on protected Annex I habitats fens and mires and protected Annex II whorl snail species.

The designation process for Natura sites commenced in Ireland in the mid 1990's. The national programme of Arterial Drainage Schemes commenced with the larger schemes in 1948 and finished in 1995. Therefore Natura 2000 site designations which overlap with Arterial Drainage Schemes include conservation aspects in a post drainage scheme environment (OPW, 2007). Adherence to the requirements of the EC (Natural Habitats) Regulations has potential to present challenges to the OPW.

1.2.1 Special Areas of Conservation (SACs)

Special Areas of Conservation were legally established as nature refuges under Article 3 of the Habitats Directive (Council Directive 92/43/EEC). The purpose of this legislation was to develop an ecological network of Special Areas of Conservation across all European Union states that collectively would be known as Natura 2000. In ecological terms there was a legal obligation for each member to identify, conserve and protect site(s) supporting rare or endangered plants, animals and their habitats (section 1.2). Designation of Irish sites was performed in accordance with the criteria set out in Annex III of the Habitats Directive.

Some of the selection parameters for SACs, used by the National Parks and Wildlife Services are:

- Importance of the site in terms of the habitats and species it supports
- Degree of representation of a habitat or habitats within a site to enhance, conserve and preserve habitat diversity
- Extent of isolation of the population
- Degree of destruction, if any, that has occurred on site
- Geographic distribution, frequency and distribution of habitats and/or protected and rare species, presence of a priority habitat and the presence of a habitat or species important or unique to Ireland (NPWS website)

Detailed in the European Council Directive (92/43/EEC) under a series of Annexes, are habitats, flora and fauna and the designation criteria for SACs. The Annex listed I to VI are described below:

- Annex I '*Natural habitat types of community interest whose conservation requires the designation of Special Area of Conservation*'. This includes priority habitats for example Calcareous fens with *Cladium mariscus* and species of the *Caricion davallianae* (7210). It also includes important habitats e.g. 'Alkaline fens (7230)' and 'Transition mires and quaking bogs (7140)' which are not priority habitats.
- Annex II: '*Animal and plant species of community interest whose conservation requires the designation of a Special Area of Conservation*'. All species listed in Annex II are deemed to be of ecological significance to Europe therefore they and their habitats are designated Special Areas of Conservation.
- Annex III: '*Criteria for selecting sites eligible for identification as sites of community importance and designation as Special Areas of Conservation*'. This is a two stage process with stage 1 considers the relative importance of Annex I habitats and Annex II considers species on a national scale. Stage 2 assesses the findings of Stage 1 in a European context.
- Annex IV: '*Animals and plant species of community interest in need of strict protection*'. This provides protection for the flora and fauna listed in Annex IV but does not

require that all habitats supporting these species be designated as Special Areas of Conservation.

- Annex V: '*Animal and plant species of community interest that taking in the wild may be subject to management measures*'. Under Irish law, namely the Habitat Regulations 1997, a licence is required for activities that results in species management.
- Annex VI: '*Prohibited methods of capture and killing modes of transport*'. This applies to the transportation, movement and proper treatment of animals and birds.

Designated as important habitats, 'Alkaline fens (7230)' and 'Transition mires and quaking bogs (7140)' are provided legal protection under Annex I of the European Council Directive 92/43/EEC. 'Calcareous fens with *Cladium mariscus* and species of the *Caricion davallianae* (7210)' are also listed on Annex I of the same directive, however this habitat is attributed priority status. Descriptions of these habitats are given in section 2.1.1.

The whorl snails, *Vertigo angustior*, *V. moulinsiana* and *V. geyeri* are all listed as Annex II species and are provided legal protection under Annex II of the European Council Directive 92/43/EEC. A description of these species is given in Section 2.1.2.

1.3 Arterial Drainage Schemes and their Maintenance

1.3.1 Introduction

Arterial drainage schemes normally included the widening and deepening of an existing channel, with some localised re-alignment, and in a few cases, the opening of a new channel. These arterial drainage schemes were carried out on a catchment wide basis under the Arterial Drainage Act, 1945. Typically, the water table would have dropped by circa one metre, although this would vary widely depending on local conditions e.g. soil, geology etc. Long sections and cross sections showing the existing levels pre works and scheme design levels, to Poolbeg Ordnance Datum, are available for the completed arterial drainage schemes and flood relief schemes at the regional headquarters. Regular maintenance works on these drainage channels are carried out by the OPW, in fulfilment of the statutory requirement under the 1945 Drainage Act, to maintain the drainage works in "*proper repair and effective condition*" (OPW, 2007).

Construction of the original Arterial Drainage Schemes required hard engineering. It usually involved widening, deepening and some straightening where required of the existing channel, and in a few cases, the opening of a new channel reach. Using draglines, work involved the excavation of all soil types e.g. clay, peat, gravel and rock. The rock was normally blasted. The channel cross section was excavated to a trapezoidal form, the channel width was standardised, longitudinal gradients were made more uniform and cross sectional beds were made even. All in-stream and riparian vegetation and soils were removed. Access for the construction plant was made along the channel banks. In schemes prior to 1973, excavated material was stockpiled on riparian lands. On post 1973 scheme works generally the topsoil was stock piled, the spoil buried and topsoil re-levelled and reseeded (OPW 2007). Scheme designs altered the channels to provide flood capacity for a minimum of the 3 year flood and to provide an outfall for drainage of adjoining lands. Where the creation of an outfall dictated the design bed levels, greater protection than the three-year flood event would have been achieved as a consequence. In the case of modern urban flood relief schemes, flood protection for a 100-200 year flood event would be the design objective (OPW 2007).

After a channel has been subject to arterial drainage scheme works, periodic maintenance is required to remove silt, encroaching vegetation and other obstructions which may affect the channel capacity (OPW 2007). Maintenance works are carried out in fulfilment of the statutory requirement under the Arterial Drainage Act 1945 and the 1995 Amendment. This requires (1) Scheme channels and associated structures to be maintained in 'proper repair and effective condition', (2) Provision of flood alleviation and outfall for the drainage of lands and maintenance of urban flood defences in accordance with scheme design standards.

Habitats and species protected under the EC Habitats Directive 1992 and Wildlife Act (1976) legislation have the same status whether they occur on an undisturbed site or have colonised an area following disturbance (i.e. drainage scheme). Such features occurring under both scenarios must be protected during drainage maintenance if the OPW is to be compliant with its statutory environmental obligations. Arterial drainage channels are maintained on a regular basis (approximately every 4-6 years); however some sites require more frequent maintenance, section by section on an annual basis, while a small proportion of the sites have not been maintained in over ten years. Some channels may only require maintenance every 20 years due to the self-cleaning characteristic of the channel (OPW 2007). This refers in particular to OPW channels that are steep and fast flowing, which may be subject to flash floods, bank erosion and rapid movement of bed gravel. However 60-70% of OPW scheme channels are of very gentle, longitudinal gradient, where deposition of silt and high growth rates of in-stream vegetation are experienced (OPW, 2007).

The majority of maintenance works are on smaller lower lying channels, with 90% of works in channels with a base of less than 3m (OPW, 2007). Channels with prolific weed growth may require maintenance annually, particularly where downstream urban bridges are at risk of being blocked due to flow of decaying vegetation in autumn. According to the CFB (2001) *"some channels have been excavated beyond the design level in the original arterial drainage works while others have become enlarged, relative to design, due to successive maintenance operations"*. This observation must be tempered with the knowledge that some channel designs were altered during construction stage to take account of unforeseen ground conditions and landowner issues.

1.3.2 Particulars of maintenance works

In most cases channel maintenance involving the removal of silt and associated vegetation from the bed of the channel is carried out by hydraulic excavators, while long reach excavators are employed in some channels. Restrictions in channels due to bank slipping or damage would be re-graded to the drainage design profile from the original scheme (OPW, 2007).

Channel breaches caused by bank erosion would be resolved by re-profiling the bank in-situ. In other cases protection material is imported such as rock armour or log poles. In addition, trees may be removed as a whole or by selective removal of lower branches, if they are considered to impinge on channel capacity. This may also occur if these trees and/or vegetation block access of the machines carrying out maintenance works (OPW 2007). The material removed in the maintenance operations is normally spread along the bank or on top of existing spoil heaps. Weed-cutting boats are engaged in a number of channels where the channels are too wide or the bank conditions too unstable to allow maintenance by excavators. In all ca. 90km of channel are cleaned annually by four weed-cutting boats (OPW, 2007). These operate seasonally and the majority of works are in the West of Ireland (OPW

2007). A new form of weed cutting excavator bucket has also been introduced in maintenance operations.



Plate 2 The OPW weed cutting boat is used in the lower sections of the Clare and Cregg Rivers near the confluence with Lough Corrib where there is sufficient draft for the vessel and where weed growth is considered excessive.

Embankments are also maintained by the OPW. Most embankment systems are tidal in nature, with some exceptions (i.e. Mulkear scheme). The frequency of maintenance for embankments tends to be less uniform than that for channels. Embankments are scheduled for works when it is deemed that the structure is in need of repair to maintain an effective condition. Repair works normally take a form of structural strengthening by improving soil and/or rock or utilising in-situ material. The in-situ material is the excavation of estuarine silt or soil generally taken from the front berm. This is placed and shaped on the existing embankment therefore restoring the embankment to its original design level. Strips of land parallel to the existing embankment, usually within 20-30m riverside of the embankment are excavated for maintenance work. In other cases structuring strengthening is achieved by importing rock and/or soil material (OPW 2007). Maintenance works also include repairs to approximately 70 structures per annum. There are 18,500 bridges including concrete pipe culverts, timber bog access ramparts and concrete or masonry abutments (OPW 2007).

2 METHODOLOGY

2.1 Introduction

This ecological assessment entitled '*Effects of Statutory Arterial Drainage Maintenance activities on Fens, Mires and Whorl Snails*' has been commissioned by the OPW to provide an assessment of the potential impacts of maintenance works on these conservation interests (fens, mires and whorl snails) as required by European legislation, namely European (Natural Habitats) Regulations, 1997. This requirement was listed in the OPW report titled '*Screening of Natura 2000 Sites for Impacts of Arterial Drainage Maintenance Operations*' (OPW 2007).

Protected Annex I habitats (for example Alkaline fens, *Cladium* fens and transition mires) and Annex II species (for example whorl snails *Vertigo angustior*, *Vertigo geyeri* and *Vertigo moulinsiana*) require designated conservation sites, known as Special Areas of Conservation (SACs). Where these sites are subject to arterial drainage maintenance activity an appropriate assessment is required, for works or operations, which are likely to have a significant effect on the conservation aspect of the site (Section 31 of the European (Natural Habitat) Regulations, 1997). All work undertaken by the OPW in SACs must lead to the maintenance of the favourable conservation status of the habitats and species for which the site is designated and the restoration of natural habitats, flora and flora communities. The objective of this ecological impact assessment was to determine the likely effects of statutory arterial drainage maintenance activities on protected Annex I habitats fens and mires and protected Annex II whorl snail species in accordance with Section 31 of the European (Natural Habitat) Regulations, 1997. Twenty SAC sites which contain the above qualifying interests and which overlap with OPW drainage channels were identified by the OPW for assessment; ten of these sites were subjected to a one day walkover assessment.

During the current survey, fen habitat and/or whorl snail habitat/populations were assessed as present or not present based on visual inspection. In instances where SAC sites are designated for fens or whorl snails, it can be for the presence of a discrete area/population within the SAC, which may or may not overlap with OPW drainage channels. As map data indicates the location of OPW drains and the extent of SAC sites, it was not possible to determine from the map whether fen or whorl snail conservation interests were present along the drains. Only field survey to assess the ground conditions will allow for the identification of these conservation interests adjacent to drainage channels.

A summary of the site synopses for these SACs are shown in Appendix 1 of this report; full site synopses are available on the NPWS website (www.npws.ie). Two of the sites originally on the list for field assessment (Ryewater SAC and Urlar Lakes SAC) were removed from the list during the current assessment following discussions with OPW as the scheduled 2008 Maintenance works were not going to proceed. Substitute sites were included i.e. River Moy SAC and Curraghchase SAC. Nonetheless, a full desk assessment of the excluded sites is included in the report. An ecological survey of the ten SAC sites selected for walkover surveys was carried out during the summer/autumn of 2008. These SAC sites overlap OPW arterial drainage maintenance and flood relief channels. Each of these ten SACs have one or more of the conservation aspects present i.e. alkaline Fens (EU code 7230), calcareous fens with *Cladium mariscus* and species of the *Caricion davallianae* (EU code 7210, priority habitat), transition mires and quaking bogs (EU code 7140) and/or whorl snail populations (*Vertigo angustior*, *Vertigo geyeri* and *Vertigo moulinsiana*). Maps showing the site walkover locations for the drainage channels within the surveyed SACs are presented in Appendix 2.

2.2 Selecting sites for field assessments

Site selection was undertaken by cross referencing OPW channels with Natura 2000 conservation sites designated for alkaline fens, calcareous fens with *Cladium mariscus*, species of the *Caricion davallianae*, transition mires, quaking bogs and whorl snail species. From the 20 SAC sites which overlap OPW drainage maintenance operations, 10 were chosen for walkover surveys as required by the project description. The sites selected were chosen as they had more than one of the relevant conservation interests. A wide geographical distribution was also taken into consideration. Table 1 shows the sites chosen for walkover surveys in this report. The object of the assessment is to establish the likely impact significance of arterial drainage maintenance on the subject conservation interests. The ecological field assessment of the SAC sites was undertaken between July and early September 2008.

Table 1 Sites chosen for field survey containing the relevant conservation habitats

Site Number	Site Name	Arterial Drainage Scheme	SAC conservation interest	Site for walkover survey
000297	Lough Corrib	Corrib Clare, Corrib Headford	Alkaline fen and <i>Cladium</i> fen	✓
000439	Tory Hill	Maigue	Alkaline fen and <i>Cladium</i> fen	✓
000440	Lough Ree	Inny	Alkaline fen	
000458	Killala Bay /Moy Estuary	Moy	<i>Vertigo angustior</i>	
000571	Charleville Wood	Brosna	<i>Vertigo moulinsiana</i>	✓
000625	Bunduff Lough and Machair/ Trawalua/ Mullaghmore	Duff	Alkaline fen	
000685	Lough Ennell	Brosna	Alkaline fen	
000688	Lough Owel	Brosna	Alkaline fen & Transition mires & quaking bogs	✓
000859	Clonaslee Eskers and Derry Bog	Brosna	Alkaline fen & <i>Vertigo geyeri</i>	✓
001398	Ryewater Valley	Ryewater	<i>Vertigo angustior</i> (also has <i>V. moulinsiana</i>)	
001571	Urlaur Lakes	Boyle	Alkaline fen	
001312	Ross Lake & Woods	Corrib Clare	Alkaline fen	
000174	Curraghchase Woods	Maigue	<i>Vertigo moulinsiana</i>	✓
002298	River Moy	Moy	<i>Vertigo geyeri</i>	✓
001774	Lough Carra/ Mask Complex	Corrib Mask	Alkaline fen & <i>Cladium</i> fen	✓
002162	River Barrow & River Nore	Kilkenny Flood Relief	<i>Vertigo moulinsiana</i>	
002241	Lough Derg, North East Shore	Killimore Carrigahorig, Killimor Cappagh	Alkaline fen <i>Cladium</i> fen	
002250	Carrowmore Dunes	Creagh	<i>Vertigo angustior</i>	✓
002279	Askeaton Fen Complex	Maigue	Alkaline fen & <i>Cladium</i> fen	✓
002299	Rivers Boyne & Blackwater	Boyne	Alkaline fen	
002301	River Finn	Deele & Swillyburn	Transition mires & quaking bogs	
002313	Ballymore Fen	Inny	Alkaline fen & transition mires & quaking bogs	

2.3 Consultation

During the current assessment consultation was undertaken with following bodies in order to obtain information relevant to the assessment:-

- National Parks and Wildlife Service (NPWS);
- English Nature (EN);
- Central Fisheries Board (CFB);
- UK Association of Drainage Authorities (ADA);
- Natural England (NE);
- Environment and Heritage Service, Northern Ireland (EHS);
- Rivers Agency, Northern Ireland (RA);
- UK Environment Agency (EA);
- Institute of Ecology and Environmental Management (IEEM);
- Irish Peatland Conservation Council (IPCC);
- UK Centre for Ecology and Hydrology (CEH).
- UK Department for Environment, Food and Rural Affairs (DEFRA).

The consultation involved direct contact by telephone / email or access of information produced by these bodies which is publically available through websites.

3 DESK REVIEW

3.1 Fens and Mires

3.1.1 Introduction

A fen is a wetland with a permanently high water level at or just below the surface. Its principal source of nutrients is from surface or ground water and the substrate is an alkaline to slightly acid peat soil. Fens tend to occur in limestone regions where their water supply is sufficiently rich in minerals. The formation of fens often occurs as ecological succession from lake basins which have become overgrown with tall reed communities. When the ice-age ended about 10,000 years ago, the ice melted and retreated leaving extensive water bodies over Ireland. Vegetation colonising the open water originated with floating plants, developing into a reed-dominated community with common reed (*Phragmites australis*), bulrush (*Schoenoplectus lacustris*) and possibly reed mace (*Typha angustifolia*) on the shoreline in suitable conditions. These plants produce a large biomass annually which accumulates on the lake bottom as partly decomposed organic material or peat. As the vegetation slowly encroached from the edges towards the centre, it ultimately engulfed the whole lake. At this point the habitat was no longer a lake, but a reed swamp. As peat continued to accumulate, rising towards the water surface, typical fen vegetation of sedges and brown mosses developed. The fen system that developed was fed by mineral rich surface and ground water. The accumulation of decaying organic material continued to fill the basin with fen peat (IPCC website).

The total area of the fen habitat in the Republic of Ireland is now 19,621 ha in 342 sites and in Northern Ireland there are 55 fen sites of conservation importance with an area of 3,416ha. There has been a 79% loss of fen habitat in the Republic of Ireland due to land reclamation, drainage, development and infilling. In The Republic of Ireland 763ha of fen is conserved. The rarest fens in Ireland are valley and basin fens (see fen types below). The majority of the Irelands fens (80%) are less than 100ha in extent and fens are also very fragmented. Fens are known to be very diverse with over 200 plants and over 600 animals have been recorded on Irish fens. Some of Ireland's most endangered rare plants and animals (ca. 25 species) survive only on fens (IPCC website). To date no national survey of fen habitat has taken place, in fact the National Parks & Wildlife Service report: '*Study of the Extent and Conservation Status of Springs, Fens and Flushes in Ireland 2007*' by Peter Foss concluded that 268 fen sites (33% of all known fen sites in Ireland) have been identified in the NPWS Fen Study database as requiring investigation to address anomalies over the fen types present on these sites and their nature conservation value.

Furthermore current knowledge on the extent of fen habitats on 102 fen sites (13%) identified in the NPWS Fen Study is completely lacking. No accurate data on the extent of fen habitats exists on an additional 600 fen sites (75%) identified within the NPWS Fen Study (Foss 2007). However, the point locations for a number of these fens are available from the NPWS as part of the NPWS Fen inventory (Foss, 2007).

Fens occur throughout the country, most commonly in the west and midlands of Ireland. Some of the better-known fenlands are Pollardstown Fen, Co. Kildare, the Shannon Callows, the shores of Lough Neagh in Northern Ireland and many lakeshores in the East Burren Region of Co. Clare. Local hydrology, pH and vegetation composition are important factors in the classification of fen sites (IPCC website).



Plate 3 Tory Hill SAC.

3.1.2 Classification

Two broad types of fen can be distinguished. Topogenous fens include those mires where water movements in the peat or soil are generally vertical. They include basin fens and floodplain fens. Soligenous fens are those mires where water movements are dominantly lateral; including valley mires, springs and flushes in the lowlands. Flushes are maintained by the movement or seepage of water and may or may not be peat-forming and in many cases are best dealt with as part of other habitats such as heathland (Fossitt, 2000). Within these two general types, fen vegetation has been traditionally classified into three basic types, 'poor-fens', 'rich-fen' and 'transition mire and quaking bog'.

Rich-fens (and associated flushes), are fed by mineral-enriched calcareous waters (pH5 or more) and are mainly confined to the lowlands, often infilling lowland lakes. Vegetation differs in species composition from poor-fens and is usually much more diverse. Rich-fen species include bog pimpernel *Anagallis tenella*, meadow thistle *Cirsium dissectum*, saw sedge *Cladium mariscus*, marsh helleborine *Epipactis palustris*, blunt-flowered rush *Juncus subnodulosus*, grass-of-parnassus *Parnassia palustris*, common butterwort *Pinguicula vulgaris*, black bog-rush *Schoenus nigricans*, and bladderworts *Utricularia* spp. Rich fen habitats include three habitats listed on Annex 1 of the EU Habitats Directive - *Alkaline fens* (7230) and *Calcareous fens with Cladium mariscus and species of the Caricion davallianae*. *Transition mires and quaking bogs* (7140) are also listed under Annex 1 of the EU Habitats Directive. (Northern Ireland Habitat Action Plan - Fens, 2005)

3.1.3 Alkaline fens

Alkaline fens are peat-forming wetlands that receive mineral nutrients from sources other than precipitation. In Ireland, alkaline fens are fed by calcium rich ground water. They occur in a variety of situations including valleys or depressions, valley head fens, within transition mires and tall reed beds, on the lowland side of hard water Oligotrophic lakeshore communities, calcium rich flush areas in blanket bogs, dune slack area, fens adjacent to raised and blanket bogs, in turlough sites, depressions in limestone pavement and wet hollows in machair, and spring fed habitats including cliffs and even saltmarsh. Alkaline fens may also occur as a secondary habitat on mined out bog sites which have been excavated to the fen peat layer (NPWS 2008).

Alkaline fens are characterised as wetlands which are mostly or largely occupied by peat- or tufa-producing small sedge and brown moss communities. These have developed on soils that are permanently waterlogged, with a soligenous or topogenous base-rich, often calcareous water supply, and with the water table at, or slightly above or below, the

substratum. Peat formation, when it occurs, is infra-aquatic (EU habitats interpretation manual). Alkaline fens may also occur with various types of swamp (such as species-poor stands of great fen-sedge *Cladium mariscus*), wet grasslands (particularly various types of Purple moor-grass *Molinia caerulea* grassland) and areas rich in rush *Juncus* species (JNCC website).

Calciphile small sedges and other Cyperaceae usually dominate the mire communities, which belong to the *Caricion davallianae*. This is usually characterised by a prominent "brown moss" carpet formed by *Campylium stellatum*, *Drepanocladus intermedius*, *D. revolvens*, *Cratoneuron commutatum*, *Acrocladium cuspidatum*, *Ctenidium molluscum*, *Fissidens adianthoides*, *Bryum pseudotriquetrum* and others (European Commission 2007). A grass-like growth of black bog rush *Schoenus nigricans*, brown bog rush *Schoenus ferrugineus*, wide leaved cottongrass *Eriophorum latifolium*, sedge species (*Carex davalliana*, *C. flava*, *C. lepidocarpa*, *C. hostiana*, *C. panacea*), blunt flowered rush (*Juncus subnodulosus*), and few flowered spike rush *Eleocharis quinqueflora* are indicative. A very rich herbaceous flora including early marsh orchid *Dactylorhiza incarnata*, narrow-leaved marsh orchid *D. traunsteineri*, fen orchid *Liparis loeselii*, musk orchid *Herminium monorchis*, marsh helleborine *Epipactis palustris*, common butterwort *Pinguicula vulgaris*, bird's eye primrose *Primula farinosa* is also evident in such habitats (European Commission 2007).

Other extra plant species given for Alkaline fens include dioecious sedge *Carex dioica*, yellow sedges *C. viridula* ssp. *Brachyrrhyncha* and *C. viridula* ssp. *oedocarpa*, Flea sedge *C. pulicaris*, lesser clubmoss *Selaginella selaginoides*, grass of Parnassus *Parnassia palustris* (O'Críodáin & Doyle 1994, 1997; Farrell & Doyle 2003; White & Doyle, 1982; Foss, 2007).

Rich fens are exceptionally endowed with spectacular, specialised, strictly restricted species. They are among the habitats that have undergone the most serious decline at a European level (European Commission 2007). There are 39 sites designated as SACs in Ireland where alkaline fen is listed as one of the key conservation interests (NPWS website). Like most peatland types in Ireland, fens have experienced a decline in quality, mostly as a result of activities such as peat mining, drainage for cropland, infilling, and fertiliser pollution and eutrophication. Only limited measures have been introduced to address these damaging activities. The overall conservation for alkaline fen habitat is bad (NPWS 2008).

3.1.4 *Cladium* Fens

Fens are usually peat-forming wetlands that receive mineral nutrients from sources other than precipitation. 'Calcareous fens with *Cladium mariscus* and species of the *Caricion davallianae*' are calcareous (calcium-rich) fens dominated by great fen sedge *Cladium mariscus*. The great fen sedge is a tall (up to 2m) and robust species with long, leathery sawtooth-edged leaves and producing clusters of red-brown flower spikes. It forms dense beds in fens. *Cladium* fens are characteristic of flat ground. The broader view is that this habitat is wetter than alkaline fens (7230) with the water table at or above the surface, though fluctuations in the water table are less (NPWS 2008).

In Ireland, *Cladium* fens occur in a variety of situations including fens found in valleys or depressions, floodplains, overgrown ditches, extensive wet meadows, within tall reed beds, on the landward side of lakeshore communities, calcium-rich flush areas in blanket bogs, dune slack areas, fens adjacent to raised and blanket bogs, in turlough sites and wet hollows in machair, fallow lands or succession stage of extensively farmed wet meadows in contact with the vegetation of the *Caricion davallianae* or other *Phragmition* species. It is often

associated with alkaline fen. *Cladium* fens are found throughout Ireland, most commonly in the midlands, west and south east (NPWS 2008).



Plate 4 Great saw sedge *Cladium mariscus* at Channel C1/17/4/7 (Askeaton Fen).

This Annex I type habitat comprises the more species-rich examples of great fen-sedge *Cladium mariscus* fen, particularly those stands enriched with elements of the *Caricion davallianae* (i.e. small-sedge fen with open low-growing sedge vegetation). Davall's sedge *Carex davalliana* itself is extinct in Ireland and the UK (Preston 2002). *Cladium* fen stands tend to occur in the following situations:

- sites where *Cladium* beds retain their species-richness owing to management
- sites have a mixture of closed, species-poor *Cladium* beds, which at their margins have transitions to species-rich small-sedge mire vegetation
- situations where *Cladium* fen is inherently species-rich, possibly owing to the fact that conditions do not allow the *Cladium* to grow vigorously and dominate the vegetation (JNCC website)

Vascular plants indicative of *Cladium* fens are; saw sedge *Cladium mariscus*, black bog rush *Schoenus nigricans*, wide leaved cottongrass *Eriophorum latifolium*, sedge species (*Carex dioica*, *C. viridula* ssp. *brachyrrhyncha*, *C. pulicaris*, *C. viridula* ssp. *Oedocarpa*), blunt flowered rush *Juncus subnodulosus*, five flowered spike rush *Eleocharis quinqueflora*, fen orchid *Dactylorhiza traunsteineri*, marsh helleborine *Epipactis palustris*, grass of Parnassus *Parnassia palustris*, and common butterwort *Pinguicula vulgaris* (NPWS 2008).

Bryophytes include; *Scorpidium scorpioides*, *Campylium stellatum*, *Drepanocladus revolvens*, *Palustriella commutata*, *Ctenidium molluscum*, *Fissidens adianthoides*, *Bryum pseudotriquetrum* (O'Críodáin & Doyle 1994; 1997; 2003; White & Doyle 1982; Foss 2007). There are 17 sites designated for *Cladium* fens in Ireland (NPWS website). Due to ongoing deterioration of *Cladium* fen habitat caused by drainage, land reclamation, peat cutting and forestry, the overall conservation assessment for this habitat is Unfavourable – Bad (NPWS 2008).

3.1.5 Transition mires and quaking bogs

Transition mires and quaking bogs are very wet mires often identified by an unstable 'quaking' surface. Transition mires and quaking bogs have characteristics that are intermediate between poor or rich fens and bog vegetation. This habitat relates to vegetation that in floristic composition and general ecological characteristics is transitional between acid bog and alkaline fens, in which the surface conditions range from markedly acidic to slightly base-rich (JNCC website). They are usually associated with the wettest parts of a mire and can be found in wet hollows, infilling depressions, or as a transitional zone to areas of open water. In the last case, the water table is determined by vertical fluctuations of the open water

body. This habitat made up of peat-forming communities developed at the surface of oligotrophic to mesotrophic waters, with characteristics intermediate between soligenous and topogenous types (European Commission 2007).

The vegetation of transition mires forms a floating mat over saturated, spongy or quaking peat and normally has intimate mixtures of species considered to be acidophile and others thought of as calciphile or basophile. In some cases the mire occupies a physically transitional location between bog and fen vegetation (JNCC website). In large peaty systems, the most prominent communities are swaying swards, floating carpets or quaking mires formed by medium-sized or small sedges, associated with sphagnum or brown mosses. They are generally accompanied by aquatic and amphibious communities. Oligotrophic water-land interfaces with *Carex rostrata* are included.

Plants indicative of this habitat include slender cotton grass *Eriophorum gracile*, string sedge *Carex chordorrhiza*, slender sedge *Carex lasiocarpa*, lesser tussock sedge *Carex diandra*, bottle sedge *Carex rostrata*, bog sedge *Carex limosa*, rannoch-rush *Scheuchzeria palustris*, bog orchid *Hammarbya paludosa*, fen orchid *Liparis loeselii*, white beak sedge *Rhynchospora alba*, brown beak sedge *R. fusca*, bogbean *Menyanthes trifoliata*, marsh willowherb *Epilobium palustre*, lousewort *Pedicularis palustris*, bog mosses (*Sphagnum papillosum*, *S. angustifolium*, *S. subsecundum*, *S. fimbriatum*, *S. riparium*, *S. cuspidatum*, *Calliergon giganteum*, *Drepanocladus revolvens*, *Scorpidium scorpioides*, *Campylium stellatum*, *Aneura pinguis*) (EU Habitat Interpretation Manual). Additional species for Transition mires include marsh cinquefoil *Potentilla palustris* and the mosses *Bryum pseudotriquetrum* and *Sphagnum denticulatum* (O'Críodáin & Doyle 1994, 1997, 2003; White & Doyle, 1982; Foss, 2007). There are 17 sites designated for Transition mires and quaking bogs in Ireland (NPWS website).

3.1.6 Threats to Fen and Mire Habitats

A change in hydrology brought about by arterial drainage has been documented to impact on the habitat by causing a gradual loss of hydrophilous (water loving) species. Initially these changes may be subtle and be detectable only by detailed monitoring. The bryophytes especially the *Sphagna* are the first species to respond in the more acidic transition mire habitat, with a decline in the pool and carpet species (e.g. *Sphagnum cuspidatum* and *S. pulchrum*) and an increase in those species tolerant of drier of conditions e.g. *S. capillifolium*. Lowering of the water table by any degree will have an impact on *Sphagnum* moss species, as these have a very narrow range of tolerance to water stress. The drainage and effective drought conditions created by arterial and land drainage will have exponential impacts on the mire and quaking bog surface (Clymo & Hayward, 1982).

Simultaneously but more slowly higher plants associated with bogs and mires will also decline and drier types of communities such as purple moor grass (*Molinia caerulea*) often become dominant. With increased aeration willow and birch may invade the fen habitats further speeding up the process. The net effect is a reduction in the variety of habitats, communities and species and the loss of the subtle nutrient and hydrological gradients which exist around the pools, streams and soaks. Drying out as a result of drainage is invariably accompanied by burning which undoubtedly accelerates the changes (Ryan, 2006).

Threats to Alkaline fens, Calcareous fens with *Cladium mariscus* and species of the *Caricion davallianae* and Transition mires and quaking bogs include;

- Overgrazing

- Restructuring agricultural land holding
- Forestry Planting
- Drainage
- Landfill, land reclamation and drying out, general
- Peat Extraction
- Hand-cutting of peat
- Mechanical removal of peat
- Water pollution
- Infilling ditches, dykes, ponds, marshes and pits
- Other human induced changes in hydraulic conditions

3.2 Whorl Snails

A total of eight species of Whorl snail are known to occur in Ireland; three of which are listed under Annex II of the EU Habitats Directive. These species are offered protection by the designation of conservation sites which extends the protected status to both the species and the habitats upon which they rely. These species are: *Vertigo angustior* (EU code 1014), *Vertigo geyeri* (EU code 1013) and *Vertigo moulinsiana* (EU code 1016).

3.2.1 General overview

Vertigo angustior, *V. moulinsiana* and *V. geyeri* are three of eight species of whorl snail (Family Vertiginidae, Genus *Vertigo*) living in Ireland. The whorl snails are amongst the smallest of the country's land molluscs with a size ranging from 1.7 to 2.2mm in height and 1 to 1.5mm in width. In one of these three species, *Vertigo angustior*, the shell is sinistrally coiled i.e. the mouth is on the left when viewed from the front, whereas all other whorl snails (and most other Irish molluscs) have the mouth on the right side. *Vertigo moulinsiana* is the largest whorl snail, with a height of 2.2 – 2.7mm. All whorl snails favour damp or wet habitats, especially marshes where they live mostly in moss, leaves and decaying vegetation. Some species of whorl snails (including *Vertigo angustior*, *V. moulinsiana* and *V. geyeri*) are particularly sensitive to changes in hydrology. Such changes have become more evident in recent times, with the result that these three species are now listed on Annex II of the European Habitats & Species Directive (Moorkens, 2007a-e).

Current OPW Environmental Drainage Maintenance Guidance notes, developed by the Central Fisheries Board, recommend retention of canary and other marginal grasses and removal of bulrush, bur-reed (sparganium) and water celery type vegetation (OPW, 2007). However, these species and habitats are recommended for conservation in scientific literature by both Moorkens and Killeen for the protection of whorl snails.

Desmoulin's whorl snail is a climbing species in emergent vegetation, living over a large vertical range at different times of year, whereas other wetland *Vertigo* species live in shorter vegetation or within the litter layer on the ground. For example, *V. antiveritigo* lives in permanently wet litter, whereas *V. angustior* lives in the more open-structured moss and decaying vegetation towards the top of the litter layer (Killeen, 2003).



Plate 5 Marsh whorl snail – *Vertigo antivertigo* (from Carrowmore Dunes SAC).

3.2.2 *Narrow mouthed whorl snail*

The Narrow-mouthed whorl snail (*Vertigo angustior*) is mainly a European species but extends through Turkey and into Iran. It ranges from southern Scandinavia to the Mediterranean and from Ireland to the Caspian Sea (Cameron *et al.*, 2003). It is a tiny mollusc with a yellow-brown coloured shell covered in fine growth ridges. The shell is unusual in being sinistral (the mouth faces to the left) (NPWS, 2008). It has a threat status of Vulnerable in Ireland (Moorkens, 2006). At a broad level, *Vertigo angustior* appears to be present in a very wide range of habitat categories of grassland, fen, marsh, salt marsh and flood plain, but the ecotone within which it is restricted means that the exact conditions which its presence demands are rare, and a lot of habitat that is “almost correct” is devoid of the snail, and other sites have an appropriate ecotone restricted to a narrow band only a few metres wide (but of variable length). Sites where the species is widespread, especially those where a variety of suitable habitats and wetness conditions occur within the one general site are of high importance. This species is hermaphrodite and often self-fertilising (Pokryszko, 1987). The main reproductive period may vary considerably depending upon meteorological conditions and species location. At some sites where this species has been recorded in the past, the main period appears to be March/April and the species reaches sexual maturity in less than a year, with maximal numbers of adults observed in the autumn (September/October) (Cameron *et al.*, 2003; Sharland, 2000; Killeen, 2003; Moorkens & Gaynor, 2003). Individuals may live for somewhat more than a year, but less than two years.

Population densities are often very high in some maritime situations with densities in excess of 1000 individuals/m² have been recorded (Killeen, 2003). Available information suggests that this species can be dispersed by various mechanisms over distances of up to 100m within a twelve month period. It has been recorded as transported by slugs and small mammals, and wind-blown litter is also likely to play a significant role (Cameron *et al.*, 2003; Falkner *et al.*, 2001).

3.2.2.1 Range

The Favourable Reference Range (FRR) for *Vertigo angustior* in Ireland is taken to be its present (post 1994) range which is 3200 km² (Moorkens, 2007a). In Ireland, the main decline of *Vertigo angustior* sites appears to be a result of loss of riverside and canal-side habitat, particularly from drainage of marshy areas in the midlands and south east. Historical losses from coastal sites possibly date back to the time period around the Irish famine, where heavy grazing of coastal grassland by traditional grazers and rabbits was more intense, and some tillage was practiced in places. As the Range of the species is based on recent range, and

covers the current known populations, it is allocated a 'Favourable' conservation status (Moorkens, 2007a).

3.2.2.2 Habitat requirements of *Vertigo angustior*

Although the macro-habitat of *V. angustior* is wide ranging, the micro-habitat, which determines the snail's area of occupancy, is much more restricted. In Ireland *Vertigo angustior* is found associated with decaying vegetation in the litter layer, or in damp moss, in open unshaded habitats. Generally it occurs in open-structured, humid litter, but in very wet conditions can climb 10-15cm up the stems of plants or onto damp decaying timber. In dry conditions it may be found in the soil, just below the litter layer. In grassland situations it occurs at the base of tussocks and in fixed dune grassland among moss patches at the edge of dune slacks. It may also be found in and under flood debris. This species requires friable and permanently moist litter, shaded by moderately tall herbaceous or grassy vegetation. It normally occurs in association with permanently moist but free-draining (permeable) soil, not subject to inundation. It is the latter requirement that makes seemingly suitable and widespread habitat unable to sustain a population of *V. angustior*. It can tolerate salt spray and brief submersion by high water spring tides. The micro-habitat occupied by populations of *V. angustior* living in dune grassland habitat is by far the most important in terms of population numbers and area of occupancy. They provide the most sustainable habitats for the species into the future.



Plate 6 View of Carrowmore Dunes SAC – *Vertigo angustior* site.

A study by the Moorkens (2007a) show there are 29 current known populations of *V. angustior*, 13 of which have been assessed for habitat quality for the snail. Habitats have been mapped, digitised, and areas of habitat estimated. Within the 13 sites it was found in this NPWS study that 52 Hectares of optimal habitat for the snail was found, 53 Hectares of optimal / suboptimal mosaic, 64 Hectares of sub-optimal habitat, and 12 Hectares of habitat with some potential for sub-optimal habitat and snail occurrence.

Optimal habitat was defined as the habitat *V. angustior* could survive in the majority (>50%) of the habitat. This allows for areas that have, for example, *Iris pseudocorus* tussocks within cropped wet grassland. The snail cannot be found high in a tussock, but the structure of the tussock provides the variation that sustains the snail within the first 5 to 6 centimetres of its base, depending on the hydrological conditions on the day. Thus to provide this amplitude of habitat variation to cover annual variation, the growth of unsuitable microhabitat is necessary. Another example of optimal habitat is fixed narrow grass grey dune habitat within dune peaks of unfixed marram grass. The topographical changes also provide the niches for wet and dry extremes; therefore by their provision for these extremes, there will always be some habitat within them that is at least temporarily unsuitable.

Sub-optimal habitat was defined as the habitat where there are patches of vegetation and conditions that support *V. angustior*, but the majority of the habitat cannot. An example would be in terrain that is generally too wet, but with small areas of sloping transition edges. From the area estimations and the quality of habitat, and extrapolating for all 29 populations, the NPWS study found it likely that there is a total of 116 Hectares of optimal habitat, and thus 58 hectares at any one time would be occupied by the snail within this habitat. In addition, there would be another 288 of lower quality habitat, where the average area of occupancy would be closer to 10%, and therefore approximately 29 Hectares would additionally be occupied, giving a total of 87 Hectares in total.

3.2.2.3 Pressures and threats

Vertigo angustior is sensitive to modification of site hydrology which affects ground-water or surface water; heavy-grazing by livestock such as cattle leading to poaching; any grazing by sheep; supplementary feeding of livestock; lack of grazing or other laissez faire management leading to scrub encroachment; vegetation burning; all forms of soil cultivation; silage production; use of fertilisers (including organic manures) and slurry spreading (including creamery waste etc.); eutrophication, including exposure to agricultural run-off giving rise to changes in plant community structure; application of pesticides (including herbicides). Exposure to leisure activities, especially on coastal sites, can have serious negative impact on *V. angustior* populations e.g. installation of caravan parks, marina development (on estuaries), motor vehicles/sports. Introduction of shrubs, e.g. *Hippophae rhamnoides*, can also be a problem on coastal sites. In Ireland, the main loss of *Vertigo angustior* sites appears to be a result of loss of riverside and canal-side habitat, exploitation of esker sites and drainage of local wetlands or more extensive areas, and sheep grazing and over exploitation of dune sites. The overall conservation status for the species is considered poor (NPWS 2008).

3.2.3 Desmoulin's whorl snail

Desmoulin's whorl snail (*Vertigo moulinsiana*) is considered to be an Atlantic-Mediterranean species with a range extending from Ireland to Russia and south to North Africa, but the main populations are in western and Central Europe. The species mainly inhabits calcareous, lowland wetlands. It occurs in swamps, fens and marshes usually bordering rivers, canals, lakes and ponds (Cameron *et al.* 2003) where very humid conditions prevail, often enhanced by open water evaporation during the spring to autumn (Moorkens 2006). *Vertigo moulinsiana* lives on both living and dead stems and leaves of tall plants: grasses (e.g. *Glyceria maxima*), sedges (e.g. *Carex riparia* and *Cladium mariscus*, and reeds (e.g. *Phragmites australis*) (Killeen 2003a, b; Cameron *et al.*, 2003). As well as the tall vegetation structure of the habitats above, *V. moulinsiana* requires a stable hydrology, where the water table is at, or slightly above, the ground surface for much of the year and any seasonal flooding is of very low amplitude (Tattersfield & McInnes, 2003). It climbs tall vegetation in the summer and autumn, and in winter it descends to litter level, and in severe conditions aestivates on the lower leaves of plants. Water-borne transportation is believed to be the principal dispersal mechanism Desmoulin's whorl snail (Killeen, 2003a; Cameron *et al.*, 2003). By the nature of its wetland habitat, the snails are likely to be able to float on the water surface or attached to floating vegetation, and can therefore disperse during periods of flooding. Dispersal is also believed to be mediated by mammals, the snail being brushed from vegetation as the animals pass, and then adhering to their body hair. A similar dispersal is inferred by attachment to the feet and feathers of birds. The ability of the species to self-fertilise makes it possible for a single coloniser to establish a new population. *Vertigo moulinsiana* is hermaphrodite, but may often

self-fertilise (Pokryszko, 1987). The eggs develop in less than two weeks, and the main reproductive period is in the summer, peak numbers of adults being recorded then, with large numbers of juveniles being recorded in the autumn. Population densities of more than 1000 individuals/m² have been recorded for this species at sites in England, but are subject to considerable annual fluctuation, the same sampling stations recording densities varying from 200 - 600 individuals/m² in successive years (Killeen, 2003a & b).



Plate 7 Desmoulin's whorl snail *Vertigo moulinsiana*.

3.2.3.1 Range

The Favourable Reference Range (FRR) for *Vertigo moulinsiana* in Ireland is taken to be 5200 km² (Moorkens, 2007c). Many of the sites lost are from riparian margins of the Grand and Royal Canals which have been cleaned and marginal vegetation has been lost. Other sites have been lost through large-scale drainage. The current range is therefore 79% of its favourable range. The Range of the species is based on recent surveys, and covers the current known populations, and it is allocated an 'Unfavourable' conservation status (Moorkens, 2007c).

3.2.3.2 Habitat requirements of Desmoulin's whorl snail

Desmoulin's whorl snail is found on tall monocotyledons at the margins of rivers, streams, ponds and lakes. However, its presence/absence and population density are largely determined by the structure and topography of the banks and the nature of the riparian management. The most suitable riparian habitats comprise a relatively broad strip where *Glyceria* or *Sparganium* spp. form dense floating rafts on gently sloping banks. Where the banks are steeper as a result of canalisation, impounding, channel dredging, and weed cutting, this habitat does not develop sufficiently and Desmoulin's whorl snail is uncommon or absent (Killeen, 2003).

V. moulinsiana requires tall vegetation structure and also requires a stable hydrogeology, where the water-table is at, or slightly above, the ground surface for much of the year and any seasonal flooding is of very low amplitude (Tattersfield & McInnes, 2003).

A study by Moorkens (2007c) show that out of the 26 current known populations of *V. moulinsiana*, 7 have been assessed for habitat quality for the snail, and habitats have been mapped, digitised, and areas of habitat estimated (Moorkens, 2007c). Within the 7 sites, 0.38 Hectares of optimal habitat for the snail was found, 5.23 Hectares of optimal / sub-optimal mosaic, 0.68 Hectares of sub-optimal habitat, and 45 Hectares of habitat with some potential for sub-optimal habitat and snail occurrence.

Optimal habitat is defined as the habitat where *V. moulinsiana* could survive in the majority (>50%) of the habitat (Moorkens, 2007c). This allows for areas that have, for example, sloping lake edges where *Phragmites* may be inundated in the downslope area for part of the year. The snail cannot overwinter in inundated vegetation, but in dry summers would descend to this humid zone until lower temperatures resumed. Thus to provide this amplitude of habitat variation to cover annual variation, the growth of temporally unsuitable microhabitat is necessary.



Plate 8 Desmoulin's whorl snail *Vertigo moulinsiana*.
(c) Roger Key, English Nature.

Sub-optimal habitat is defined as the habitat where there are patches of vegetation and conditions that support *V. moulinsiana*, but the majority of the habitat cannot. An example would be in terrain that is generally too dry, but with small areas of wet depressions. From the area estimations and the quality of habitat, and extrapolating for all 26 populations, there is likely to be a total of 1.41 Hectares of optimal habitat. In addition, there would be another 145.5 Hectares of lower quality habitat, where the average area of occupancy would be closer to 10%, and therefore approximately 15 Hectares would additionally be occupied, giving a total of 16.5 Hectares in total (Moorkens 2007c).

Relatively high groundwater also contributes to maintaining a high humidity in the vegetation. Conversely, conditions must not become so wet that aquatic plants such as watercress (*Rorippa nasturtium-aquaticum*) and fool's watercress (*Apium nodiflorum*) become dominant. Permanent flooding of reedbeds may also be detrimental as there will be no litter layer in which the snails can over-winter, and no sites for laying eggs (Killeen & Moorkens, 2003).

3.2.3.3 Pressures and threats

Vertigo moulinsiana is considered to be a species that is dependent upon the conservation of habitat and preservation of high water levels and is therefore classified as vulnerable (Seddon, 1997). Its IUCN Irish local threat status in Moorkens (2006a) is also "Vulnerable". Drainage of wetlands has been the principal cause of the species' decline throughout its European range. In Ireland, the greatest loss of *Vertigo moulinsiana* sites has been through drainage of wetlands, and riparian management of the Grand and Royal Canals. Further pressure on habitats through spread of urban development is likely. Table 3 summarises the pressures on *Vertigo angustior*, *Vertigo geyeri* and *Vertigo moulinsiana* (Killeen 2003a). The overall conservation assessment of this species is unfavourable – bad (NPWS 2008).

Drainage of wetlands has been the principal cause of the snail's decline throughout its European range. However, there are many additional factors applicable at any site that could adversely affect Desmoulin's whorl snail populations (Killeen, 2003):

- Changes in hydrology, such as water abstraction and general drainage of wetlands leading to reduced water tables and loss of periodic flushes.
- Channelisation of rivers, deepening of drainage channels and creation of vertical profiles to riverbanks, eliminating wetland and marginal marsh habitat.
- Regular cutting of riparian margins of rivers and tidying of riverside paths.

3.2.4 *Geyer's whorl snail*

Vertigo geyeri is considered to be under threat in Ireland (Moorkens, 2006b). It is stringent in its requirement of saturated water conditions in calcareous, ground water fed flushes that are often limited in size to a few metres square. These habitats are generally found in mosaics of suitable patches within wider fen macro-habitats, which in Ireland can themselves fall within wider site habitats that can be as diverse as raised bog laggs, transition mires, lake shores, hill or mountain slopes, and wetlands associated with coastal dunes and machair (Moorkens, 2003). Within these macrohabitats, however, the snail is consistent in where it lives, within the saturated and decaying roots of small sedges (particularly *Carex viridula* ssp. *brachyrrhyncha*), associated fen mosses (particularly *Drepanocladus revolvens* and *Campyllum stellatum*). Within its macro-habitat, the snail needs constancy of hydrological conditions, but with enough variation to provide refugia for the meteorological extremes that the habitat must endure. It requires an openness of habitat that prevents succession by shade loving plants and more competitive shade loving snails.

This species is hermaphrodite but may often be self-fertilising with some cross fertilisation (Pokryszko, 1987). One to ten uncalcified, separated eggs are produced which have a 2 week development period (Falkner *et al.* 2001). The main reproductive period may vary considerably from site to site and depending upon meteorological conditions. At some sites the main period appears to be March/April and the species reaches sexual maturity in less than a year, with maximum numbers of adults observed in the autumn (September/October) (Cameron *et al.* 2003). However, at a site in Anglesey, a study by Sharland (2000) found that there was an extended and variable breeding season with no clear annual cycle. Individuals may live for somewhat more than a year, but less than two years. Population densities seem frequently to be low, but previous studies show that up to 200 individuals per square metre have been recorded (Killeen 2003). Dispersal mechanisms are uncertain, but hypotheses include transport by charadriiform birds and/or grazing animals (including wild ungulates), dependent upon circumstance (Cameron *et al.* 2003). The ability of the species to self-fertilise makes it possible for a single coloniser to establish a new population.

3.2.4.1 Range

The sites for *Vertigo geyeri* range in their area of macro-habitat, from less than 1ha to over 100ha (such as Ben Bulbin springs) in size (Moorkens 2007b). *Vertigo geyeri* is specific in its macro- and micro-habitat requirements, particularly with respect to ground water levels and vegetation composition. Therefore, suitable habitat within any site may be very restricted, but also immediately recognisable. In large sites such as Ben Bulbin, *Vertigo geyeri* is widespread over a large area but suitable flush habitat could be as little as a few hundred square metres. In smaller sites, there may only be tens of square metres. There is unlikely to be more than 5 hectares of Ireland occupied by *Vertigo geyeri* at any one time, but the exact area of occupancy

varies from year to year depending on local hydrogeological conditions. *Vertigo geyeri* is considered to be a relict species, and unlikely to naturally colonise new sites with ease. It is therefore conservation dependent in terms of species spread (translocation is likely to be necessary if new sites are to be colonised) and protection of current sites. It is currently considered to be threatened in the Republic of Ireland with a local IUCN status of Vulnerable (Moorkens, 2006). As the Range of the species is based on recent range, and covers the current known populations, and it is considered that this range can be sustainable for the species in Ireland if all sites are conserved, it is allocated a 'Favourable' conservation status (Moorkens 2007b).

3.2.4.2 Habitat requirements of Geyer's whorl snail

Suitable *Vertigo geyeri* habitat within sites is often very small in area and localized. These are generally scarce and fragmented habitats in Ireland (Moorkens 2007b). A study by Moorkens (2007b) show that for the 28 current known populations of *V. geyeri*, the maps of the 20 that have been assessed for habitat quality for the snail have been digitised and areas of habitat estimated (Moorkens 2007b). Within the 20 sites, 1.16 Hectares of optimal habitat for the snail was found, 5.18 Hectares of optimal / suboptimal mosaic, 22 Hectares of sub-optimal habitat, and 2.38 Hectares of habitat with some potential for sub-optimal habitat and snail occurrence.

Optimal habitat is defined as the habitat where *V. geyeri* could survive in the majority (>50%) of the habitat (Moorkens 2007b). This allows for areas that have, for example, *Schoenus nigricans* tussocks. The snail cannot be found high in a tussock, but the structure of the tussock provides the variation that sustains the snail within the first 5 to 6 centimetres of its base, depending on the hydrological conditions on the day. Thus to provide this amplitude of habitat variation to cover annual variation, the growth of unsuitable microhabitat is necessary. Another example of optimal habitat is cropped open sedge swards and moss carpets within undulating terrain. The topographical changes provide the niches for wet and dry extremes; therefore by their provision for these extremes, there will always be some habitat within them that is at least temporarily unsuitable.

Macrohabitats associated with this species are listed in Cameron *et al.*, 2003 as follows:

- Annex I habitat 7140, transition mires (but not quaking bogs): (Corine 54.5)
- Annex I habitat 7210 (calcareous fens with *Cladium mariscus* and species of the *Caricion davallianae*): fen-sedge beds (Corine 53.3)
- Annex I habitat 7220 petrifying springs with tufa formation (Cratoneurion; Palustriella) (Corine 54.12)
- Annex I habitat 7230 (alkaline fens – low sedge-rich communities): rich fens (Corine 54.2)

These are generally scarce and fragmented habitats in Ireland, and suitable *Vertigo geyeri* habitat within sites is often very small in area and localized (NPWS 2008).



Plate 9 C1/30 Section F Island Lake fen, Moy SAC, near Knock Co Mayo. *Vertigo geyeri* occurs at this site.

Sub-optimal habitat is where there are patches of vegetation and conditions that support *V. geyeri*, but the majority of the habitat cannot. This can be due to terrain being generally too high, but with small suitably wet runnel flushes occurring within, or where habitat is on the margin of base tolerance for the species, where acid influence promotes mainly calcifuge species, but where occasional groundwater seepage influence provides a suitable patch that the snail can occupy. Alternatively the snail may be restricted by succession due to lack of grazing, where the snail is shaded out of most of the area, except for patches prevented from growth by being wetter than their surroundings. The study by Moorkens (2007b) show that from the area estimations and the quality of habitat, and extrapolating for all 28 populations, there is likely to be a total of 1.6 Hectares of optimal habitat. In addition, there may be another 42.6 Hectares of lower quality habitat, where the average area of occupancy would be closer to 10%, and therefore approximately 4 Hectares would additionally be occupied, giving a total of about 5 Hectares in total (Moorkens 2007b).

Some general favourable habitat indicators are:

- Average height of vegetation: *Schoenus* tussocks not more than 75cm, sedge/moss lawns 5-15cm
- Plant species composition: Very favourable condition: Yellow sedge lawn, in particular with *Carex viridula* subsp. *brachyrrhyncha*, mosses *Drepanocladus revolvens*, *Campylium stellatum*, tussocks of *Schoenus nigricans*
- Other favourable plant species indicators: *Pinguicula vulgaris*, *Briza media*, *Equisetum palustre*, *Juncus articulatus*
- Ground saturated
- Spring flow with network of dendritic trickles
- Site management: appropriate light grazing

A decline in favourable condition of the habitat is implicated by the following conditions:

- A reduction in ground moisture levels
- An increase in ground moisture levels
- Spring flow channelled
- An increase of *Filipendula ulmaria* or *Molinia caerulea*
- An increase in *Menyanthes trifoliata* or *Juncus subnodulosus* monoculture
- An increase in scrub cover compared to the baseline
- A change in management regime to under- or over-grazing

3.2.4.3 Pressures and threats

A basic requirement for *V. geyeri* is maintenance of the existing hydrological regime, so management practices that alter site hydrology or hydrogeology (whether ground water or surface water are affected) can be very damaging to it. Such management practices could be damaging whether carried out on-site or elsewhere in the catchment supporting the hydrology of the site. Nutrient enrichment, whether from agricultural run-off, use of fertilisers (including organic manures) or slurry spreading, can also be damaging, as would be pesticide use (including herbicides). Sheep-dip run-off would be especially damaging. Any form of soil cultivation (including ploughing) is inimical to the survival of this snail. Heavy grazing (particularly by large, heavy breeds of beef cattle), or use of supplementary stock-feeding facilities on-site, is damaging to this species. Changing of grazing species from sheep to cattle leads to a decline in habitat quality. Scrub encroachment, whether by native species or exotic conifers seeding themselves into the site from neighbouring conifer plantations, can cause habitat alteration leading to loss of this species. Burning of vegetation is similarly harmful. The overall conservation status is considered poor (NPWS 2008).

3.2.5 Habitat Associations, Pressures and Threats to Whorl Snails

Vegetation species and height can have an important impact on the abundances of whorl snails. Table 2 presents a flora species list, ranking these plants from Class I (most favourable to whorl snails) to Class IV (least favourable for whorl snails).

Ground moisture levels can have a major impact on whorl snails. Different levels of moisture and their effects were documented in Killeen & Moorkens (2003). Ground moisture levels are listed on a scale of 1-5. Suitable ground moisture levels for whorl snails are levels 2-4.

1. Dry. No visible moisture on ground surface.
2. Damp. Ground visibly damp, but water does not rise under pressure.
3. Wet. Water rises under light pressure.
4. Very wet. Pools of standing water, generally less than 5 cm deep.
5. Site under water. Entire sampling site in standing or flowing water over 5cm deep.

Table 3 shows the habitat type associated with each type of whorl snail surveyed in this report, this information is taken from the series of conservation assessments on these species Moorkens (2007a & b). The interpretation of the results can be assessed using the factors mentioned in 'Monitoring Desmoulin's Whorl Snail *Vertigo moulinsiana*', Killeen & Moorkens (2003). Whorl snail populations can fluctuate naturally over time as a result of its limited life span (10 to 17 months) and short-term changes in environmental conditions that rapidly influence population size. If habitat or hydrological conditions become untenable for the snail, the species can rapidly be lost from a site, but individuals may also persist for a while in less than ideal conditions, or in small suitable pockets within a predominantly declining site. A year with very low recorded numbers may not necessarily be interpreted as a long-term population decline, but can be interpreted with the benefit of all the collected snail and environmental information. Seasonal weather conditions can have a significant impact on population levels. Population size may be higher during wet, humid summers, while periods of drought or changes to site management, such as increased grazing or mowing, result in lower population levels. For these reasons, information on the snail's area of occupancy, vegetative habitat and hydrological conditions must be used in combination with relative abundance to assess conservation status (Killeen & Moorkens, 2003).

Table 2 Classification of plant species in whorl snail habitats (Adapted from Killeen & Moorkens 2003)

Class I	Class II
Reed sweet-grass (<i>Glyceria maxima</i>)	Reed canary-grass (<i>Phalaris aurundinacea</i>)
Lesser pond-sedge (<i>Carex acutiformis</i>)	Common reed (<i>Phragmites australis</i>)
Tufted sedge (<i>Carex elata</i>)	Branched bur-reed (<i>Sparganium erectum</i>)
Greater tussock-sedge (<i>Carex paniculata</i>)	Meadowsweet (<i>Filipendula ulmaria</i>)
Greater pond-sedge (<i>Carex riparia</i>)	Stinging nettle (<i>Urtica dioica</i>)
Great fen-sedge (<i>Cladium mariscus</i>)	
Class III	Class IV
Water-mint (<i>Mentha aquatica</i>)	All other species
Ambibious bistort (<i>Persicaria amphibium</i>)	
Willowherbs (<i>Epilobium</i> spp.)	

Some general indicators of favourable habitat are (Killeen & Moorkens, 2003);

- Average height of vegetation not less than 70 cm when measured in August.
- Plant species composition and cover: *Glyceria maxima*, *Carex* spp., *Cladium mariscus*, *Sparganium erectum* and *Iris pseudocorus* indicate favourable conditions, as can *Phalaris aurundinacea*
- Ground moisture levels between 2 and 4
- Site management: light or rotational grazing or no grazing.

A decline in habitat condition is implicated by the following (Killeen & Moorkens, 2003);

- A reduction in ground moisture levels.
- A significant rise in water levels due to penning so that aquatic plants such as watercress (*Rorippa nasturtium-aquaticum*), and fool's watercress (*Apium nodiflorum*) become dominant.
- An increase in rank herbs, particularly nettle (*Urtica dioica*), thistle (*Cirsium*) spp. meadowsweet (*Filipendula ulmaria*), great willow-herb (*Epilobium hirsutum*) and butterbur (*Petasites*) spp., with vegetation height increasing or decreasing beyond parameters.
- An increase in scrub cover compared to the baseline.
- A change in management regime or intensity – heavy grazing and poaching of banks indicate Unfavourable management. The species is also unlikely to survive where riverbank vegetation is regularly cut for angling activities.
- A decrease in river water quality leading to eutrophication and changes in nutrient status of marginal vegetation.

Moorkens (2007a & b) highlights the principal pressures facing whorl snail populations in Ireland. Table 4 presents these pressures referring to the habitat and ecosystem changes affecting each species of whorl snail.

From the desk study review it was found that the scientific literature published in Ireland relating to the conservation status and requirements of fen habitat indicate that land drainage and drying of wetland habitats has a significant, detrimental impact on fen and mire habitat (Doyle & Ó Críodáin, 2003; EHS, 2005; Foss, 2007; NPWS, 2008)

The reliance of whorl snails on these habitats indicates that the significance of impact of drainage activities on fen and mire habitats has direct repercussions for these species (Killeen

& Moorkens 2003; Killeen 2003a; Killeen 2003b; Moorkens 2003; Moorkens & Gaynor 2003; Moorkens 2006; 2007 a-e). It is noted that in most cases the word 'drainage' and phrase 'drainage maintenance' are interchangeable among non-engineering persons. Arterial drainage maintenance involves the periodic removal of silt and associated vegetation from the channel in a manner that re-establishes the hydrological regime of the channel to that generated at scheme works stage.

From scientific literature and publications in the Irish context there was found to be a general consensus indicating the significant impact of drainage activities on fen and wetland habitats; indicating a potential disparity in the reporting of impacts relating to drainage and those relating to drainage maintenance. In a hydrogeological report on the Danganbeg Wetland system the existing drainage channels constructed for the drainage of land for agricultural output were found to have a significant negative impact on the fen habitat, in particular facilitating the removal of mineral rich spring water from tufa-forming springs (Arup, 2005).

The Groundwater Body Description prepared by the GSI for the Askeaton area refers to a degradation of the fen at Ballinavirick due to recent drainage impacting the local hydrology (GSI website).

The Shannon River Basin District Characterisation Report (RPS, 2005) identified 18 groundwater bodies associated with dependent surface water ecosystems as being *probably at risk* due to pressures affecting their water balance. The pressure involved being Arterial Drainage near the ecosystem boundary. Further studies are required under the Water Framework Directive to determine whether drainage maintenance imposes a significant impact for these 18 groundwater bodies, which include Askeaton Fen and Tory Hill SAC sites.

In the recent national study on fen habitats commissioned by the NPWS, it was found that drainage (particularly the original schemes) has significantly reduced the extent of low-lying fen habitat (Foss, 2007). However, good examples of this type of fen remain alongside the River Shannon and its tributaries.

The impacts of land drainage are internationally recognised as having a significant negative impact on wetland habitats. In particular Naiman *et al.* (1990) found that government subsidised funding for the drainage of land for agricultural output resulted in a distortion of the economic cost benefit, particularly in relation to wetland ecotones. At an international level damage caused by drainage of land for agriculture and the importance of wetland ecosystems has now been reversed in a recent shift to the restoration of these habitats (Biebighauser, 2007). The importance of wetland ecosystems and the recent shift to the restoration of these habitats is also reflected in Holden *et al.* (2004).

Table 3 Habitat associations of the whorl snails, *Vertigo angustior*, *V. moulinsiana* and *V. geyeri*

Habitats	<i>V. angustior</i>	<i>V. moulinsiana</i>	<i>V. geyeri</i>
Water fringe vegetation: reedbeds and large sedge communities e.g. <i>Glyceria maxima</i> swamp, <i>Carex elata</i> swamp, <i>Typha/Phragmites</i> beds, most communities of Corine 53 (water-fringe vegetation), especially: common reed beds, dry <i>Phragmites</i> beds (53.112), reedmace beds (53.13), medium-tall waterside communities (53.14), reed sweetgrass beds (53.16), and large <i>Carex</i> beds (53.21)		✓	
Annex I habitat 7140, transition mires (but not quaking bogs): (Corine 54.5)			✓
Annex I habitat 7210 (calcareous fens with <i>Cladium mariscus</i> and species of the Caricion davallianae): fen-sedge beds (Corine 53.3)		✓	✓
Annex I habitat 7220 petrifying springs with tufa formation (Cratoneurion; Palustriella) (Corine 54.12)		✓	✓
Annex I habitat 7230 (alkaline fens – low sedge-rich communities): rich fens (Corine 54.2)		✓	✓
Fixed dunes: fixed coastal dunes with herbaceous vegetation (HD Annex I habitat category 2130), grey dunes (Corine 16.22)	✓		
Dune Slacks: humid dune slacks (HD Annex I habitat 2190, Corine 16.3)	✓		
Unimproved, climax maritime grassland (where it occurs close to, but not in, seasonally flooded dune slacks): ecotone between grey dunes (Corine 16.22) and humid dune slacks (Corine 16.3)	✓		
Machair (HD Annex I habitat 21A0)	✓		
Humid tall herb communities: meadowsweet (<i>Filipendula</i>) stands and related communities (Corine 37.1)	✓		
Limestone pavement Natura 2000 Code 8240 Corine 62.3 Talus slopes (of usually calcareous boulders) with some deciduous trees Corine 62.1 (<i>Fraxinus</i> , <i>Tilia</i> , <i>Ulmus</i>)	✓		
Alder (<i>Alnus</i>) swamp forest (central Europe) Corine 44.91	✓	✓	
Well-drained (almost always on slopes), open, deciduous forest (frequently dominated by <i>Fraxinus</i>) on the coast of southern Scandinavia Corine 41.34	✓		
Saltmarsh/grey dune transition (ecotone between grey dunes (Corine 16.22) and saltmarsh couch beds (Corine 15.35))	✓		
Saltmarsh/dune heath/lowland heath transition (ecotone between saltmarsh (Corine 15.3), heather brown dunes (Corine 16.24) and Atlantic <i>Erica-Ulex</i> heaths (Corine 31.23)	✓		
Calcareous fen/unimproved humid grassland transition (ecotone between fen-sedge beds (Corine 53.3) or rich fens (Corine 54.2) and eutrophic humid grasslands (Corine 37.2)	✓		
Marsh/unimproved grassland transition (ecotone between marsh and Atlantic and sub- Atlantic humid meadows (Corine 37.21)	✓		
Lake margins/well-drained unimproved neutral to calcareous grassland transition (no applicable Corine code)	✓		
Unimproved, lightly grazed/mown, humid grassland: Atlantic region - Atlantic and sub- Atlantic humid meadows (Corine 37.21), and Continental region – subcontinental <i>Cnidium</i> meadows (Corine 37.23)	✓		
Unimproved lightly grazed (by rabbits) maritime grassland: semi-natural maritime grassland	✓		
Unimproved, lightly-grazed grassland at the margins of alluvial floodplain systems: ecotone of Atlantic and sub-Atlantic humid meadows (Corine 37.21) with alluvialflooded, eutrophic, humid grasslands (Corine 37.2)	✓		

Table 4 Current pressures on populations of whorl snails (Killeen 2003a; Moorkens 2007a-e)

Pressures	V. <i>angustior</i>	V. <i>geyeri</i>	V. <i>moulinsiana</i>
Cultivation: change in agricultural practice e.g. from low intensity grazing to arable/hay/silage	✓	✓	✓
Use of pesticides: <i>Vertigo</i> spp. are susceptible to agricultural and other pesticides	✓	✓	✓
Fertilisation: <i>Vertigo</i> spp. are susceptible to nutrient enrichment from artificial and natural fertilisers and requires low nutrient habitat	✓	✓	✓
Grazing: increases in grazing levels and changes to current grazing practice (lengths of grazing periods)	✓	✓	✓
Abandonment of pastoral systems	✓	✓	
Undergrazing: from loss of habitat due to excessive shade and scrub encroachment	✓	✓	✓
Forestry planting: afforestation <i>Vertigo</i> spp. habitat results in its total destruction		✓	✓
Stock feeding: supplementary feeding of stock in snail habitat	✓	✓	✓
Burning: Burning in large fen habitats results in loss of available habitat			✓
Agriculture and forestry activities not referred to: introduction of exotic sea buckthorn and other species for the purposes of protection from wind and for other purposes	✓		
Sand and gravel extraction: loss of habitat in esker / wetland interface habitats	✓		
Peat extraction: whether hand or machine cut, cutting of <i>Vertigo</i> spp. habitat or nearby habitat resulting in hydrological or other knock-on changes can result in its total destruction		✓	✓
Urbanised areas, human habitation: if encroachment into <i>Vertigo</i> spp. habitat is allowed	✓	✓	✓
Communications networks: where encroachment into <i>Vertigo</i> spp. habitat is allowed, or interferes with the hydrogeology of the habitat for the species.		✓	✓
Paths, tracks: trampling erosion and fragmentation of habitat, replacing bankside habitat with hard tracks	✓	✓	✓
Golf courses: Loss of habitat from golf courses without very extensive areas of rough	✓		
Camping and caravans: continuing expansions of Caravan Parks or other intensification	✓		
Walking, horse-riding and non-motorised vehicles: habitat is lost through erosion	✓	✓	✓
Motorised vehicles: habitat is lost through erosion and fragmentation, particularly where cars are driven on to sensitive fen habitats	✓	✓	
Water pollution: <i>Vertigo moulinsiana</i> is sensitive to eutrophication and consequent vegetation changes to its riparian and fen habitats			✓
Landfill, land reclamation and drying out		✓	✓
Drainage: changes in hydrology particularly from ditch deepening or abstraction and digging out of springs	✓	✓	✓
Flooding: from hydrogeological changes resulting in higher than acceptable water levels in the snail habitat	✓	✓	✓
Modification of hydrographic functioning: <i>V. Geyeri</i> is sensitive to changes that affect as little as 10mm differences to the water table at its habitat.		✓	
Modifying structures of inland water course: many sites have been lost through increasingly intensive management of canal and river systems			✓
Sea defence or coastal protection works: through modification of natural and dynamic coastal habitats	✓		
Erosion: coastal erosion both natural and through trampling damage	✓		
Other processes: climate change, in particular leading to higher sea levels and subsequent erosion of habitat, and leading to changes of weather pattern causing more extensive flooding and/or drought periods	✓	✓	✓

4 FIELD STUDY RESULTS

4.1 Fens and mires

The SAC sites surveyed for drainage maintenance impacts to fen and mire habitats included:

- Askeaton Fen SAC
- Tory Hill SAC
- Lough Corrib SAC
- Lough Owel
- Lough Carra/Lough Mask Complex SAC

4.1.1 Askeaton fen

Askeaton Fen Complex consists of a number of small fen areas to the east and south east of Askeaton in Co. Limerick. The site is a candidate SAC selected for *Cladium* fen and also for alkaline fen, both habitats listed on Annex I of the E.U. Habitats Directive. Works were carried out on channel C1/17/4 of the Maigne CDS this year using a silt bucket. Channel C1/17/4/4 was walked and checked with the local NPWS conservation ranger before works took place.

No work has been done in channel C/1/17/4/7 this year. Improved grassland was recorded from either side of the bridge at the road. This channel is very overgrown with reed canary grass and water cress. Fen habitat was recorded within 100m of this drainage channel, indicating that the grassland habitat adjacent to the drainage channel had been drained and improved from former wetland habitat as per the designs of the original Drainage Scheme and the ongoing maintenance at this location.



Plate 10 High water levels adjacent to channel C1/17/4/7. Fen habitat is visible to the right of this image.

The downstream section of C1/17/4 has very steep sides and a very high spoil heap to the right hand side. This part of the channel has improved grassland either side. It runs parallel with C1/17/4 for approximately 100 metres. This channel is very overgrown with common reedmace, fool's watercress, water mint and branched bur-reed. There is scrub at the edges of this channel in places, comprising gorse and bramble. Works were scheduled to take place in this channel in early autumn. The NPWS ranger also walked this channel in advance of works.

Channel C1/17/4/7 is bordered by the SAC on both sides 100m perpendicular to the road. There is *Cladium* sedge present where the two drains C1/17/4 and C1/17/4/7 intersect in the townland of Ballinvirick. There is alkaline fen on the RHS of this channel and improved

grassland on LHS 100m in from the road, this then changes to fen also. This drain is very overgrown leading to extensive water-logging of both the SAC and improved grassland habitats at this location. Ongoing drainage of these lands would be expected to impact on the hydrological conditions supporting this priority Annex I fen habitat.



Plate 11 Fen south of Lough Nagirra with Tory Hill in the background.

4.1.2 Tory Hill

Tory Hill is an isolated wooded limestone hill situated about 2 km North East of Croom, Co. Limerick. Lough Nagirra is located within the SAC and has a thick fringe of Common Reed (*Phragmites australis*) and, in association with it, areas of alkaline fen and calcareous fen vegetation referable to the Caricion davallianae alliance with Saw Sedge (*Cladium mariscus*). Both of these fen types are listed on Annex I of the E.U. Habitats Directive, the latter with priority status. Tory Hill is also designated for areas of orchid-rich calcareous grassland, a habitat that is listed with priority status on Annex I of the E.U. Habitats Directive; it is found on the eastern side of the hill and on its summit.



Plate 12 Lough Nagirra, a view from the channel C1/23 (south)

Drainage maintenance works have been carried out on channel C1/23 of the Maigue CDS in the past 12 months at Corrabul, outside of the SAC site. The SAC designation includes both Tory Hill and Lough Nagirra. Channel C1/23 enters Lough Nagirra from the north and exits from the southwest end of the lake. No works are to be done on this channel in the SAC this year, as advised by the NPWS. The sides of this channel up to >10 metres each side were found to be affected by drainage, as the botanical communities were dominated by species indicative of a drier habitat. This was found to be partly due to the spoil heaps deposited on the fen in the past. The channel within the SAC near the lake is now very overgrown with fool's water cress, common reed and reed canary grass.



Plate 13 C1/23 upstream of Lough Nagirra looking over to Tory hill. Very overgrown part of the channel.



Plate 14 Channel C1/23/4 flows from outside the SAC into Lough Nagirra.

Channel sections C1/23 to the north of Lough Nagirra and channel C1/23/4 were maintained last year. The northern channel borders the SAC and the bank on this site was left untouched. Works in channel C1/23/4 stopped ca. 100m before the intersection with the SAC. Maintenance works at these drains includes vegetation removal with a silt bucket and the resultant water entrained vegetation and silt placed on the improved grassland side.

Lough Nagirra was found to be surrounded by Alkaline fen with species including angelica *Angelica sylvestris*, knapweed *Centurea nigra*, yellow rattle *Rhinanthus minor*, common reed *Phragmites australis*, sedges *Carex spp.*, meadowsweet *Filipendula ulmaria*, purple loosestrife *Lythrum sylvatica*, willow species *Salix spp.* and water mint *Mentha aquatica*.

Land surrounding channel C1/23/4 within the SAC was found to have become very dry and overgrown with obvious drying of the adjacent fen habitat. The OPW propose to remove weeds within the channel. Fen habitat adjacent to this channel contains species such as sedges *Carex spp.*, devil's bit scabious *Succisa pratensis*, silverweed *Potentilla anserina*, tufted hair grass *Deschampsia caespitosa*, purple moor grass *Molinia caerulea* and willow species *Salix spp.* This area also had areas of tall herb habitat and the channel was bordered in sections by improved agricultural grassland.

4.1.3 Lough Corrib

Again, this is a very large site with a wide range of conservation interests. A summary of the relevant conservation interests of this site are provided in Appendix 1. A number of selected areas only were visited to assess impacts of ongoing maintenance activities on fen and mire habitats. Alkaline fen was recorded from channel C/27 of the Corrib Clare CDS within the SAC. Flora species included black bog rush *Schoenus nigricans*, bogbean *Menyanthes trifolia*, purple moor grass *Molinia caerulea*, common spearwort *Ranunculus flammula*, water mint

Mentha aquatica and devil's bit scabious *Succisa pratensis*. Calcareous grassland was also recorded and included such species as common eyebright *Euphrasia nemorosa*, yellow rattle *Rhinanthus minor*, common reedmace *Typha latifolia*, sneezewort *Achillea ptarmica*, ox-eye daisy *Leucanthemum vulgare* and selfheal *Prunella vulgaris*. The drainage channel outside the SAC was bordered by degraded blanket bog and semi-improved agricultural grassland, while fen habitat dominated the terminal end of the channel at Lough Corrib, within the SAC. Land improvement and grazing was noted to have impacted the diversity and sward height on the northern side of the channel, as can be seen from Plate 16; however, fen habitat along the lake shore was not found to be impacted by the existing drainage channel.



Plate 15 Channel C/27 (Lough Corrib SAC), this channel was flanked by fen and improved agricultural grassland.



Plate 16 C/27 in the SAC (Lough Corrib) at the end of lake was dominated by fen habitat.

4.1.4 Lough Owel

Lough Owel is a large hard water lake, a habitat listed on Annex I of the EU Habitats Directive. The lake is located approximately 4km north-west of Mullingar. The site is of major conservation significance, containing, as it does, three habitats that are listed on Annex I of the EU Habitats Directive, i.e. alkaline fens, transition mires and hard water lakes. Lough Owel (site 000688) is designated for three Annex I habitats.

The primary channel for maintenance within the Lough Owel site is the River Brosna, where it exits the lake at the southern shore. Additional drainage channels within the catchment were surveyed. All channels within this catchment were found to be significantly overgrown and dominated by reed and tall sedge swamp with species including bur-reed *Sparganium erectum*, soft rush *Juncus effusus*, yellow iris *Iris pseudocorus*, fool's water cress and great willowherb. The invasive non-native Indian balsam was recorded from the drainage channel south of Lough Owel. No fen habitat was recorded from this section of the SAC. However, there are whorl snail records within the vicinity of Lough Owel and potentially within drainage channels which require separate consideration.



Plate 17 View of Lough Owel south shore



Plate 18 Overgrown channel south of Lough Owel with tall reed and wet grassland vegetation

4.1.5 Lough Carra/Lough Mask

Again, this is a very large site and a number of selected areas only were visited to assess impacts of ongoing maintenance activities on fen and mire habitats. Channels CM/8/2 and CM/9/1 at the northern shore of Lough Mask were found to be heavily encroached with common reed and emergent vegetation. Habitats on either side of the drains included diverse wet grassland and *Molinia* meadow which was recorded from CM8/2 upstream of Lough Mask, and which may be impacted by drainage maintenance; however, it is proposed to maintain this channel using a weed cutting bucket in order to minimise the likelihood of over-digging and the subsequent increase in localised drying out of adjacent wetlands. Channel CM/9/1 on Lough Mask was dominated by willow *Salix* spp. and gorse *Ulex europeaus* on the banks, while common reed *Phragmites australis* was found to be encroaching within the main channel. Although fen habitat occurs commonly along the shore of Lough Mask and within inlets of the lake, no fen habitat was recorded from the lands adjacent to the drainage channels surveyed.



Plate 19 Fen habitat recorded from the northeastern portion of Lough Carra, near Deerpark, Co. Mayo.



Plate 20 CM5/12 and CM5/13 at the northern portion of Lough Carra near Deerpark, Co. Mayo

Channel CM5/12 located in the townland of Deerpark, at the northern end of Lough Carra was found to transect *Cladium* fen habitat at the intersection with the lake. Lough Carra is bordered by common reedmace *Typha latifolia* and bulrush *Shoenoplectus lacustris*. Drainage maintenance works affecting the hydrology of this location could potentially have significant negative impacts on this fen habitat. Habitats in the vicinity of this drain include improved grassland, treelines and scrub.

Channel CM5/10 had been recently maintained by weed cutting boat or weed cutting bucket. This drain is bordered by diverse wet grassland both sides with tall herb and reed swamp vegetation along the margins. There is alder *Alnus glutinosa* and willow *Salix spp.* along the bankside. There was no evidence of fen habitat within the surveyed area on this channel and no impacts to fen habitat were noted.

Table 5 Drainage channels identified during the study where drainage maintenance is expected to affect fen and mire habitats

Site Number	Site Name	Arterial Drainage Scheme	OPW Channels affected	SAC conservation interest affected and assessment of potential significance
000439	Tory Hill	Maigue	C1/23 C1/23/4	Alkaline fen recorded from directly adjacent to the drainage channel. The drying out impacts of drainage maintenance works may have significant negative impacts on this habitat.
002279	Askeaton Fen	Maigue	C1/17/4 C1/17/4/7	Alkaline fen and <i>Cladium</i> fen recorded directly adjacent to proposed drainage maintenance works. Likely significant negative impact.
000297	Lough Corrib	Corrib	C27	Alkaline fen recorded from the western shore of the lake near Moycullen village. Improved land recorded from one side of the drain, however, impact of drainage on fen habitat not noticeable. No longterm data available.
000688	Lough Owel	Brosna	Drains adjacent to River Brosna at Farranistic k	This site is designated for alkaline fen, transition mires & quaking bogs. These habitats were not recorded from the surveyed drainage maintenance sites at the southern side of the lake. No longterm data available.
001774	Lough Carra/Lough Mask	Corrib Mask	CM5/12 CM5/13 CM5/10 CM9/1 CM8/2	Alkaline fen and <i>Cladium</i> fen recorded from Deerpark townland on Lough Carra, drainage maintenance works may potentially impact these habitats. No longterm data available.

4.2 Whorl snails

A summary of the SAC sites surveyed for whorl snail populations were:

- Carrowmore Dunes SAC
- Charleville Woods SAC
- Clonaslee Eskers and Derry Bog SAC
- River Moy SAC
- Lough Owel SAC

Additional SAC sites containing whorl snails are further detailed in this section where specific information and field data were recorded in the current assessment; these sites included Curraghchase Woods SAC, adjacent to Askeaton Fen in Co. Limerick, the River Barrow/River Nore SAC and Killala Bay/Moy Estuary SAC.

There are recent records of whorl snail species from all of the above designated sites (NPWS 2008), resulting in their inclusion in the current ecological impact assessment. Surveys for whorl snails were limited to the zone of direct impact from the drainage maintenance works, i.e. the channel banks and the water margin of the drains and channels. From this zone whorl snails were recorded from only one location, within the water's edge emergent flora within channels at the Carrowmore Dunes SAC complex.

At Charleville Wood SAC it was found that drainage maintenance works were being carried out mainly on sections of the channels that were outside of suitable whorl snail habitat and were therefore not impacting on these species. However, other areas scheduled for maintenance works could potentially have significantly affected this site (i.e. outflow from the lake which could not be accessed due to road construction works).

4.2.1 Carrowmore Dunes

Carrowmore Dunes are situated on the south-western coast of County Clare, roughly midway between Milltown Malbay and Kilkee. Carrowmore Dunes (site 002250) is designated for four Annex I habitats and one Annex II species, *Vertigo angustior*. Works were taking place in the OPW drain directly opposite the Doonbeg golf hotel at the wide bend in the channel (grid IQ 98528 66929). OPW confirm that work had recently been carried out on the first thirty metres of the channel outfall but that further works observed during the course of this site visit were not being carried out by or on behalf of the OPW.

The species recorded at this location was *Vertigo antiveritigo*, a more common *Vertigo* species not designated under the EU Habitats Directive. This species was also recorded from the upstream end of the drain where the drain is now diverted under the road. Snails were recorded in the wet grass and tall reed swamp (*Phragmites australis*) at the edge of the drains where *Holcus lanatus* and *Glyceria fluvialis* were subject to periodic submergence and exposure.

The current assessment did not carry out hydrological or hydrogeological investigations into the impacts of drainage maintenance in relation to drying out of ground conditions and the indirect impacts this would incur for whorl snail populations in proximity of maintained drains and watercourses within designated conservation sites. Suitable *V. angustior* habitat was recorded from within the vicinity of the network of drainage channels at this site; however none of these species were recorded from the margins of the drains. Drainage of the

surrounding wet grassland habitats is expected to impact on this species indirectly. This species was recorded from the grid square Q9968 during 2006 (NPWS 2008).



Plate 21 The drainage channel at the eastern portion of the site was found to contain suitable whorl snail habitat.

No snails were recorded from the wet grassland or grey dune habitat surrounding the land drains within the SAC site, however they have previously been recorded from these locations. Flora at these locations was considered diverse and representative of the calcareous habitats present.



Plate 22 Carrowmore Dunes OPW drain with *Phragmites* reeds and emergent reed/sedge/grass banks suitable for *Vertigo moulinsiana*.



Plate 23 Drainage maintenance works at Carrowmore dunes. Whorl snails (*V. antiverigo*) were recorded from this drain. Works were being carried out by an unknown individual and not in accordance with OPW EDM guidelines.

4.2.2 Charleville Wood

Charleville Wood is a large Oak woodland surrounded by estate parkland and agricultural grassland, located about 3 km south-west of Tullamore. The site is notable for the presence of a large population of *Vertigo moulinsiana*.

At the time of the survey construction works in relation to the N52 Tullamore Bypass were ongoing so access into the site was restricted. No work had been undertaken on the Clodiagh

River by the end of September 2008. Works were undertaken on an afferent stream entering Charleville lake. It is possible that these works affected areas where whorl snails are present. However, as no works were undertaken on the outflow from the lake (which appeared to be underground and was also being affected by the N52 construction works) there would not have been any wider indirect impacts on this designated area.



Plate 24 Recently maintained drainage channel within Charleville Woods SAC



Plate 25 The Clodiagh River at Charleville Woods

The works completed were limited to the maintenance of a drain flowing into the lake. Site surveys within the SAC were carried out on channels where maintenance works had been undertaken. These included channels C8/8, C8/7 and C8/19 of the Brosna CDS. Works in channel C8/19 had been completed for this year. This channel was bordered by a tall herb corridor >5m with species such as great willowherb, marsh woundwort, bindweed, sycamore, creeping bent *Agrostis stolonifera*, elder *Sambuca nigra* and goosegrass *Galium aparine*. No whorl snails were found along the damp margin of this drain. Wet bog woodland and mixed woodland were recorded along the border of and within the SAC.

4.2.3 Derry Bog and Clonaslee Esker

This site, near Clonaslee, is noted for *Vertigo geyeri* and alkaline fen. Whorl snails were not recorded at the sites investigated, however the drainage channels intersecting the site were found to contain suitable emergent vegetation for *V. moulinsiana* including *Sparganium erectum* and *Phragmites australis*, species which are targeted for removal during drainage maintenance works. No suitable fen habitat was recorded where *V. geyeri* may occur; as the preference of this species for ground-fed calcareous fen or quaking mires means its habitat requirement is under severe pressure even within designated conservation sites. No long term habitat data was readily available to assess if the fen status has reduced. However a small area of calcareous wet grassland with a number of the botanical indicator species for *V. geyeri* habitat (*Schoenus nigricans*, *Carex* spp., etc.) was searched for the presence of this species. It is considered that the absence of grazing, and the lack of wet flushes within this

habitat meant that this was overall suboptimal for this species. Works in the vicinity of Derry Bog and Clonaslee Esker SAC were focused on maintenance of the Clodiagh River and the drainage network within this catchment. Drains surveyed included C3/13C, C3/13F C3/13.



Plate 26 Drain C3/13F perpendicular to the R421 with whorl snail potential



Plate 27 Calcareous grassland habitat north of Derry Bog

Bog habitat was cutover with *Molina* meadow (an Annex I habitat) grading into heath. The populations of *Vertigo geyeri* are considered unfavourable; this is due to the absence of overall trend data and also to the loss of naturalness of this habitat, which is considered unrecoverable (NPWS 2008).



Plate 28 Drain on Derry Bog with whorl snail *V. moulinsiana* potential

4.2.4 Moy SAC

Island Lake was significantly affected by the original River Moy drainage scheme in the 1960s. These works resulted in the lowering of water levels in the lake to the point where it is now limited to seasonal flooding during the winter period. However the lake bed has been colonised by a rich calcareous fen and is now included within the River Moy SAC. The OPW

maintain a number of channels within the area of this fen; principally channel C1/30 Section F which is maintained by weed boat.

The whorl snail *Vertigo geyeri* has been recorded from this fen in 2003 (NPWS 2008) and the site is also recognised for the presence of rare flora and fen habitat. *V. geyeri* was not recorded during the site walkover but the site was found to contain suitable habitat, along with a number of Annex I fen habitats of conservation importance. The maintenance of drainage channels within Island Lake is considered a considerable pressure at this location. The OPW consider that in the absence of long term data on water levels or habitats there remains the possibility that the habitat is partly dependant on the maintenance works maintaining the current hydrology.



Plate 29 Moy Catchment F/15 36 Drainage channel with emergent vegetation upstream of Mannin Bridge, close to Mannin and Island Lakes NHA.

4.2.5 Lough Owel SAC

Desmoulin's whorl snail *V. moulinsiana* has been recorded from the south east corner of Lough Owel at Farranistick (Grid N4256) in 2004 (NPWS 2008). The current survey took place in this area. The OPW currently maintain only one channel at this location, which is the River Brosna main channel (C45/1). No whorl snails were recorded from this channel during the current survey.



Plate 30 Small reed/sedge fen at Lough Owel south shore, east of River Brosna outflow

Table 6 Drainage channels identified during the study where drainage maintenance is expected to affect whorl snail populations.

Site	Site Name	Arterial	OPW	SAC conservation interest affected and assessment
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Number		Drainage Scheme	Channel	of potential significance
002250	Carrowmore Dunes	Creegh		<i>Vertigo angustior</i>
000571	Charleville Wood	Brosna		<i>Vertigo moulinsiana</i>
00859	Derry Bog and Clonslee Esker	Brosna		<i>Vertigo geyeri</i>
000688	Lough Owel	Brosna		<i>V. moulinsiana</i>
002298	River Moy	Moy		<i>V. geyeri</i>

4.3 Additional sites

Curraghchase Woods SAC was included in the current study as the OPW are responsible for the maintenance of a drainage channel C1/17/4 which also transects fen habitat within the Askeaton Fen SAC. *Vertigo angustior* has been recorded from this location (Grid R4148: NPWS 2008) and suitable whorl snail habitat (for *V. moulinsiana*) was recorded from the drain margins during the current survey where marginal grass species had been left intact during maintenance works.



Plate 32 Downstream of bridge at Curraghchase, reed canary grass was left intact during maintenance as required by current EDM practices. This protected whorl snail habitats in this area.

Whorl snails (*V. moulinsiana*) have been previously recorded from the River Barrow/River Nore SAC at a number of locations including Durrow and Abbeyleix, and also recently recorded from Borris in Co. Carlow (NPWS 2008). Suitable riparian habitat has been recorded at a number of locations within the SAC where reed sweet grass, reed canary grass and reeds colonise the river margins. The maintenance of the Kilkenny scheme would not in any way affect these species. Killala Bay/Moy Estuary SAC is recognised as containing an important population of *V. angustior*, at Killanley Glebe (Grid G264248), last recorded in 2006 (NPWS 2008). The OPW are responsible for drainage maintenance works within the Killala Bay/Moy Estuary SAC there are no drains for maintenance in the vicinity of the *V. angustior* population at Killanley. There is a stream which forms the county boundary with Mayo and Sligo which is maintained by the OPW due south of this site at Castleconnor; however, this does not interact with the hydrology of the stream and protected marsh at Killanley.

The Ryewater SAC site is located between Leixlip and Maynooth. It extends along the Rye Water, a tributary of the River Liffey. The Rye Water in Carton Estate is dammed at intervals, creating a series of lakes. The Rye Water itself is the only drainage channel in this SAC (channel C1), and the OPW carry out maintenance on the main channel within the SAC. A previous study of this SAC was found to have an unfavourable extent of optimal habitat for *Vertigo angustior*. It was found to be dry and limited in 2006 (Moorkens 2007a).

The marsh, mineral spring and seepage area found at Louisa Bridge supports a good diversity of plant species, including Stoneworts, Arrowgrass (*Triglochin palustris*), Purple Moor-grass (*Molinia caerulea*), Sedges (*Carex* spp.), Common Butterwort (*Pinguicula vulgaris*), Marsh Lousewort (*Pedicularis palustris*), Grass-of-parnassus (*Parnassia palustris*) and Cuckooflower (*Cardamine pratensis*). The mineral spring found at the site is of a type considered to be rare in Europe and is a habitat listed on Annex I of the EU Habitats Directive. The semi-aquatic snails *Vertigo angustior* and *V. moulinsiana* occur in marsh vegetation near Louisa Bridge; both are rare in Ireland and Europe and are listed on Annex II of the EU Habitats Directive. The main importance of the site lies in the presence of several rare and threatened plant and animal species, and of a rare habitat, thermal, mineral, petrifying spring. The Ryewater valley (site 001398) is designated for one Annex I habitats and two Annex II species: the whorl snails *Vertigo moulinsiana* and *Vertigo angustior*.

The Urlaur Lakes SAC site comprises three small hard water lakes, a habitat listed on Annex I of the EU Habitats Directive. The lakes (Lough Nanoge, Lough Roe and Urlaur Lough) lie in the Upper catchment of the Lung River, a major tributary of the Boyle River. The site is located approximately 10 km north of Ballyhaunis in Co. Mayo. As part of the Boyle River Drainage Scheme the OPW maintain a single channel (C1/24) to the south of the SAC. This borders the SAC at the south east corner of the site, where the outfall from the lakes joins the main channel at Cloonroe Bridge, in the townland of Cummer. The OPW does not carry out drainage maintenance on the channel between the interconnecting lakes; neither does the OPW carry out maintenance works on the lakes themselves.

Swamps and reedbeds fringe the open water of the three lakes in places. These are generally dominated by Common Club-rush (*Scirpus lacustris* subsp. *lacustris*) with occasional Saw Sedge (*Cladium mariscus*), Water Horsetail (*Equisetum fluviatile*) and Bogbean (*Menyanthes trifoliata*). At the western end of Lough Roe is an extensive quaking area of swamp vegetation. Bulrush (*Typha latifolia*), Common Reed (*Phragmites australis*) and Ragged Robin (*Lychnis flos-cuculi*) are common here and willows (*Salix* sp.) are colonising in places.

The shorelines consist of shallow mineral soils with flush vegetation dominated by Black Bog-rush (*Schoenus nigricans*). In most cases, this is backed by agricultural grassland. Elsewhere the shoreline is peaty and is backed by cutaway bog or flush/marsh vegetation. The southern portion of the site, north of the OPW drainage channel (C1/24) is designated within the SAC and given its low-lying topography may contain fen and wetland habitat which could be affected by drainage maintenance activities within the adjoining channel. Ling Heather (*Calluna vulgaris*), Purple Moor-grass (*Molinia caerulea*) and Royal Fern (*Osmunda regalis*) are abundant on the cutaway. In some places there is flushed, species-rich heath with Lesser Butterfly-orchid (*Platanthera bifolia*), Pyramidal Orchid (*Anacamptis pyramidalis*), Heath Spotted-orchid (*Dactylorhiza maculata*), Meadow Thistle (*Cirsium dissectum*), Quaking-grass (*Briza media*) and Bog-myrtle (*Myrica gale*). Urlaur Lakes SAC (site 001571) is designated for three Annex I habitats, one of which is alkaline fen.

5 IMPACT ASSESSMENT

5.1 Impacts of drainage maintenance affecting fen and mire habitats

Impacts affecting fen and mire habitats resulting from drainage schemes have been identified in scientific literature and in the ongoing research and management carried out by the NPWS. However, a distinction has to be made between the impacts to fen and mire habitats incurred during the creation of drainage networks and the impact incurred during the ongoing drainage maintenance operations. The immediate impacts of drainage are mostly restricted to the narrow corridor of the drain and adjacent land. However the presence of a drain can have a long-term impact on the hydrology and ground water levels within fen and mire habitats and on the wetland habitat required by whorl snails, causing these habitats to slowly dry out by increasing the surface run-off from adjacent lands. Where this is the case the ecological integrity of these habitats will continue to deteriorate.

The purpose of this report is to assess the potential impacts of on-going maintenance of these drains on fens, mires and whorl snails.

Drainage maintenance can potentially result in direct ecological impacts. This can take the form of the removal and/or alteration of the plant, invertebrate and vertebrate communities associated with the watercourse. Maintenance operations will have direct impacts on communities within the watercourse, while the removal of bankside vegetation will affect the riparian habitat. The placing of water entrained silt and vegetation adjacent to the channel can alter the botanical communities of the bankside habitat. Machine access to channels can directly impact on habitats along the route chosen; however, the OPW maintain that placing of spoil and machine access is occurring for over fifty years along many of the channels with the associated environmental impacts having shaped the current environment.

The original drainage schemes within alkaline fen, *Cladium* fen and transitional mire habitats are considered to have had a detrimental impact on these habitats and species either directly or indirectly, this is evidenced by the localised drying out of fen and wetland habitat adjacent to these drains and the reclamation of these lands for agricultural use as recorded during the field surveys undertaken during the current assessment. The hydrological integrity of an alkaline fen, *Cladium* fen and mire habitat can be affected by drainage potentially resulting in a reduced ecological value, with the possible loss of some pools and some specialised fen and mire plants and invertebrates and the creation of a more uniform habitat.

However, drainage maintenance impacts, the focus of this assessment, may be short term, depending on the frequency of maintenance, allowing subsequent re-colonisation of the drainage channel and banks. However, particular plants, invertebrates and other animals may not survive or thrive with continual maintenance, being affected by opportunistic and ruderal species which may have a competitive advantage in a drier soil environment. This could include the encroachment by scrub or alien plant species and may result in an alteration in the vegetation of these semi-natural habitats and the irreversible succession of these habitats from wetland sites to modified terrestrial habitats. The extent to which this has already occurred, given the historical extent of Drainage schemes and ongoing maintenance over many decades and the ongoing effects of drainage maintenance is currently unknown.

It is therefore important to determine if the presence of arterial drains and continued drainage maintenance is resulting in the continual decline in these fen and mire habitats and

the habitats of whorl snails. This will only be established from long term scientific monitoring of the extent and expansion or contraction of these habitats and species populations. The correlation of groundwater/surface water levels within these sensitive habitats and drainage maintenance intervals will provide a long term picture of the ongoing impact of maintenance. These may take the form of joint studies with NPWS.

In the absence of ground water monitoring data relating to the impact of drainage maintenance works on fen and mire habitats it is not possible to draw direct conclusions on the impact of drainage maintenance. The flow rate of surface and ground water from a fen or wetland habitat is considered to be potentially affected by drainage maintenance.

Ongoing drainage maintenance is required to bring channels to the Scheme Design level; in a drain which has not been maintained for four to six years the conveyance capacity would be expected to have deteriorated due to weed growth and siltation. This will also affect the capacity of the drain to remove water from the surrounding lands including fen habitat. The fen or adjacent wetland habitat may experience a higher water table and damper ground conditions during the maintenance interval. Upon maintenance of the drain to reinstate Scheme capacity, the capacity to draw water away from the surrounding lands is expected to increase, resulting in increased drainage of the fen habitat and a drying out effect. The OPW maintain that this creates a cyclical effect where deposition during the interval may result in increased waterlogging of surrounding soils. However, there is no long term data available in Ireland to determine whether the flora and fauna communities of fen habitats can survive this ongoing wetting and drying process, or indeed to what extent does the drying out caused by drainage maintenance revert to wetting during the maintenance interval. The parallels between this cyclical process and the natural fluctuations in fen habitat ground water levels, influenced by precipitation levels, are also understudied.

The hydrological regime surrounding medium to high gradient channels would have a stable low-flow datum with some increase in the flood-flow datum building up over a few years. For low gradient channels, both the low-flow and flood-flow water levels would tend to rise by 50 to 300mm over a few years and is then returned to the original design datum. This is an ongoing process and ensures that the level of drainage provided to the riparian lands and the flood protection originally provided by the Arterial Drainage Schemes is retained OPW (2007).

Drainage maintenance is considered to hold some of the sites in ecological balance given that many of the channels have undergone six to eight maintenance cycles since the schemes were constructed. To demonstrate this, scientifically hydrometric monitoring at fen habitat sites would need to be undertaken before, during and after maintenance works.

Maintenance works are carried out in fulfilment of the statutory requirement under the Arterial Drainage Act 1945 and the 1995 Amendment. This requires Scheme channels and associated structures to be maintained in 'proper repair and effective condition', and the provision of flood alleviation and outfall for the drainage of lands and maintenance of urban flood defences in accordance with scheme design standards. Long sections and cross sections showing the existing levels pre works and scheme design levels, to Poolbeg Ordnance Datum, are available for the completed arterial drainage schemes and flood relief schemes at the regional headquarters.

The purpose of such maintenance works is to maintain channel conveyance at the 'design level' of the original scheme by removing the inevitable accumulations of silt, vegetation and other debris.

Long term monitoring data is required to provide sufficient data to adequately assess the impacts of drainage maintenance. However, the precautionary principle applies in that drainage and drying out of Annex I fen habitats has been scientifically shown to significantly negatively impact fen habitats. Therefore, in the absence of data, regard must be taken of the potential for ongoing maintenance operations in these drains to have a significant negative impact on fen and mire habitats over a long term time scale. The required assessment must take into account the conservation status of the Annex I fen habitats, which exist in their current form as a result of the original Drainage Schemes. This should aim to ascertain the management requirements of SAC sites designated for or including Annex I fen habitats, on the basis that these habitats now exist in a post-drainage environment.

5.2 Impacts of drainage maintenance affecting whorl snail species

Potential impacts affecting whorl snails are directly related to drainage maintenance activities which may result in possible further drying out of wetland habitat and a reduction in the availability of damp ground. The potential loss of such suitable habitat for Annex II listed whorl snail species within Annex I habitats, where these sites are afforded SAC conservation status would be considered a significant negative impact. However, the impacts of drainage maintenance have not been established and the extent of potential habitat loss would require further investigation.

In addition, the margins of drainage channels present suitable ecotones for *Vertigo* species, where damp, marginal vegetation remains despite drying out of the surrounding habitats. However, maintenance activities currently threaten these bankside habitats during the removal of silt, instream and bankside vegetation using conventional buckets or indeed weed buckets, which specifically remove the vegetation upon which the whorl snails depend. The OPW state that steps 1 to 7 of the Environmental Drainage Maintenance guidelines will result in a reduction of impacts from drainage maintenance practices, although these guidelines have not been developed in line with the conservation interests of whorl snails and amendments to these guidelines are required to reduce impacts to these species.

The extent of impacts to whorl snails from drainage maintenance within designated conservation sites is currently unknown. However, extrapolating the findings of this study it is considered that whorl snail populations utilising the margins of the drain and/or reliant on the continuity of wetland habitats directly adjacent to the drainage channel could be significantly negatively impacted by drainage maintenance works. No monitoring data for the populations of whorl snails within drains was available to scientifically assess the potential impact of loss of river corridor habitat or adjoining wetland habitat within these SACs which overlap with Drainage Schemes. Water abstraction and general drainage of the channels may lead to reduced water tables and loss of periodic flushes through an increase in flow through and drainage capacity. This in turn will have a significant negative impact on the whorl snail optimal habitat conditions. Impacts to these protected habitats and species can be mitigated by ecologically sensitive working practices such as those set out in the OPW environmental drainage maintenance guidance notes.

It is not possible to quantify the extent of whorl snail populations lost during drainage maintenance activities at a national level, nor was it considered feasible to quantify the populations of whorl snails within the scope of this study. From the publication by Killeen

and Moorkens (2003) it is clear that the required survey extent would be far greater than the resources allowed by this project. Further study is also required to establish the impact of dislodging whorl snails with the cutting of emergent and riparian vegetation and the distribution and downstream colonisation/survival rates of these species. The OPW will consult with experts in NPWS regarding individual channels within or impinging on SAC's which are designated for the protection of whorl snails. This will help to identify key channels or channel lengths for which the retention of existing drainage outfall and flood mitigation requirements can be balanced against environmental protection of whorl snail and their habitats.

Further drying out of fen habitat could potentially lead to an alteration in land use with the loss of semi natural habitats and the introduction of grazing or fertilizer regimes which would result in the alteration of both the botanical diversity of the habitat and the availability of ecotones for whorl snails. Land improvements were brought about by the original drainage and it is reasonable to conclude that no further improvements are likely to occur.

6 MITIGATION MEASURES

The hydrology / hydrogeology requirements of fen and mire habitats and the associated habitat requirements of whorl snails place an imperative on the OPW to maintain these conditions within designated conservation sites where these ecological interests are present in the vicinity of drainage networks. Given the unfavourable conservation status of fen and mire habitats and of whorl snail species in Ireland (NPWS, 2008) it is recommended that the OPW engage in consultation with the NPWS on a site by site basis to ensure that ongoing maintenance works are in line with the conservation requirements for the protection of these habitats and species.

It is recommended that all SACs containing fen and mire habitats and whorl snail species should be overlapped with OPW GIS mapping to highlight situations where drainage maintenance may interact with these conservation interests and where possible databases held by the NPWS, such as the Fen Inventory database (Foss, 2007) is cross referenced with the OPW GIS.

Immediate consultations are recommended with experts in NPWS in order to identify key channels or channel lengths for which the retention of existing drainage outfall and flood mitigation poses a significant impact to the conservation interests of the SAC sites and whereby drainage maintenance requirements can be balanced against environmental protection of fen and mire habitat and whorl snail species. Consultation with NPWS is recommended in relation to the specific fen and whorl snail sites identified in the walk-over findings of the current study, with regard to the potential impacts arising from ongoing drainage maintenance at these sites. Following consultation these key channels or channel lengths may then require further ecological assessment prior to any drainage maintenance works to assess the location of these conservation interests, the spatial extent of these interests and the potential significance of impacts within these identified sites.

It is recommended that OPW consult with the experts in NPWS on individual channels within or impinging on SAC's which are designated for the protection of fen and mire type habitats. This will help to identify key channels or channel lengths for which the retention of existing drainage outfall and flood mitigation requirements can be balanced against environmental protection of these habitat types. From these consultations consideration should also be given to carrying out long term monitoring at key representative locations on a select number of these channels.

The current assessment has identified the potential for changes in hydrology / hydrogeology occurring due to arterial drainage maintenance and the subsequent effects on sensitive fen and mire habitats and the habitats of whorl snail species. The quantification of these changes in terms of spatial and temporal effects is crucial to the long-term conservation of the fen and mire habitat and also the wetland habitat of the whorl snails. Substantial changes in hydrology will have detrimental effects on these habitats and species. It is recommended that the OPW consult with the NPWS to assess the need for groundwater and surface water monitoring in and adjacent to drainage channels within designated sites.

Where water level monitoring data and appropriate ecological assessment concludes that a European designated site will be adversely affected, works may not go ahead unless there are imperative reasons of overriding public interest, as stated in the EU Habitats Directive, 1992. Where a priority Annex I habitat is affected (such as *Cladium* fen within the current assessment), only overriding public interests relating to human health or public safety can

proceed and notice of approval of such works must be supplied to the European Commission. Given the legislative significance of designated European conservation sites and the diversity of pressures the conservation interests within these sites are currently facing, it is considered that there is merit in the establishment of some form of water level management plan. This could be integrated into the Water Framework Directive process through the relevant River Basin Management Plans and associated public consultation.

Further research carried out under the WFD monitoring programme will result in the availability of additional data regarding the status of groundwater and surface water catchments in Ireland, including a number of designated sites included in the current assessment. Recommendations from these studies will aim for the water bodies to achieve 'Good Status'. In other sites where there is an absence of informed expert opinion, this report has found that the collation of field data on a site by site basis is required to establish the significance of drainage maintenance impacts on fen and mire habitats, or on groundwater dependant habitats which support whorl snails.

Hydrological data requires long time periods to establish trends and sound scientific data and accordingly, sites need to be monitored for a number of years to gather this improved understanding.

Consideration should be given to placing water entrained silt and vegetation, removed during drainage maintenance, back from the water's edge and in cases where drains are at level with surrounding fen or wetland habitat, specific disposal locations will be required in order to minimise the disruption and damage to fen or mire habitat or to whorl snail populations occurring along the water's edge or within the damp ground conditions adjacent to the channel. Suitable locations for the disposal of spoil will vary depending on the sensitivity of the banks and the extent of fen habitat or suitable whorl snail habitat along the margins of the drain/watercourse which may require assessment by a suitably qualified ecologist and depending on the options available, the approval of the landowners concerned.

Vegetation which is favoured by whorl snails e.g. reed canary grass, reed sweet grass and tall sedges, including bur-reed (*Sparganium erectum*) and bulrush (*Typha* spp.) which occur within channels affected by drainage maintenance should be retained where possible, as this vegetation has been found to be favoured by whorl snail species. Both bulrush and bur-reed are listed for removal in Step 4 of the OPW's Environmental Drainage Maintenance Guidance Notes. The CFB are currently contracted to OPW to develop a Phase II of the OPW Environmental Guidelines and training for staff and it is therefore recommended that these EDM steps be amended for designated conservation sites within which whorl snails are a listed conservation interest by the CFB. It is further proposed that the OPW consider the implementation of these mitigation measures at a national level within all locations where whorl snails have been recorded as conservation interests for designated SAC sites.

Over deepening of channels to below the Arterial drainage Scheme design will impact on the fen hydrology. In some cases, the presence of a bridge or culvert floor downstream of the Fen may act as a water level control and in other cases no control is present to maintain the water level to at least the Scheme Design datum. It is recommended that the OPW review the relevant channels which overlap with fen habitats and establish the presence of a low water level control or install some form of an excavation benchmark where no control exists. In channels where the primary conveyance restriction is aquatic vegetation, weed cutting buckets should be utilised to reduce impacts on the channel bed and prevent any possible bed deepening. Weed cutting buckets have additional benefits in reducing the number of whorl

snails and other aquatic Annex II species impacted by the removal of channel substrate and bankside vegetation. OPW state that over-deepening of channels on drainage maintenance is not occurring to any significant extent.

Discussion with the NPWS is recommended to determine a concerted plan for the conservation of these habitats and species which allows for the fulfilment of OPW duties in flood relief and drainage maintenance, while allowing for the protection and enhancement of the conservation status of these ecological interests. It is NPWS policy that in the absence of a completed management plan for any conservation site, the conservation objectives include maintaining or restoring the 'favourable conservation status' (defined in the EU Habitats Directive for habitats and species) of habitats and species for which the site has been selected, including the habitats of the annexed species.

The OPW have Standard Operating Procedures in relation to Invasive species in order to reduce the risk of spread or introduction of invasive non-native species. This involves the identification of risk and the adoption of appropriate mitigation measures.

7 CONCLUSIONS

From the desk study review it was found that the scientific literature relating to the conservation status and requirements of fen habitat indicate that land drainage and drying of wetland habitats has a significant, detrimental impact on fen and mire habitat (Doyle & Ó Críodáin 2003; EHS 2005; Foss 2007; NPWS 2008). The reliance of whorl snails on these wetland and fen habitats indicates that drainage activities on fen and mire habitats has direct repercussions for these species (Killeen & Moorkens 2003; Killeen2003a; Killeen 2003b; Moorkens 2003; Moorkens & Gaynor 2003; Moorkens 2006; Moorkens 2007 a & b). However, the broad conclusion that these wetland and groundwater dependant habitats and associated species are affected by drainage does not encompass the potential impacts relating to the ongoing impacts of drainage maintenance.

It is considered that where drainage maintenance results in the ongoing, long-term drying out of surface water and groundwater dependant habitats that this would constitute a significant impact. It is suggested that further scientific study is required to establish the drying out effect on ongoing drainage maintenance on wetland and fen habitats, particularly within European designated conservation sites, i.e. SACs. It is also noted that in the scientific literature that the term 'drainage maintenance' is not used as a separate term to 'drainage'.

According to their website the NPWS are currently preparing Conservation Site Management Plans, a number of which are currently available for download online (<http://www.npws.ie/en/PublicationsLiterature/ConservationManagementPlans>); however, none of the sites assessed in the current report are available for public consultation at this point. The availability of these management plans would be advantageous for any stakeholder or interested party working within a designated site. The NPWS policy on this issue maintains that in the absence of a completed management plan for any site, the conservation objectives include maintaining or restoring the 'favourable conservation status' (defined in the EU Habitats Directive for habitats and species) of habitats and species for which the site has been selected, including the habitats of the annexed species. It is the prerogative of the individual or party proposing or carrying out works in the site to ensure that this is observed.

Constraints due to gaps in existing data were noted during the current assessment. This provides scope for future scientific study to be carried out by the OPW. The availability of data relating to the spatial and temporal impacts of OPW drainage maintenance works are currently outstanding:

- To what spatial extent if any does arterial drainage maintenance dry out fen habitat and is this spatial area increasing within ongoing maintenance i.e. are larger and larger areas of SAC sites being dried out or is it confined to a corridor either side of drainage channels. Irrespective of this it is important to note that drying out of fen habitat even within a defined corridor is considered a significant negative impact, particularly with regard to *Cladium* fen (priority Annex I habitat), as recorded at the Askeaton Fen SAC.
- To what extent does fen habitat recover during the maintenance interval or has this area been permanently degraded. This must be assessed on a site by site basis in consultation with experts in NPWS and in utilising long term monitoring data interpreted by both hydro-geologists and ecologists. A programme for consultation and the relevant monitoring, to be developed by the OPW in conjunction with the NPWS, is a key finding of this ecological assessment.

- To what extent do the groundwater levels fluctuate within a fen/mire habitat based on the drainage maintenance intervals and what is the impact on the habitat from this activity.
- As ongoing works have the potential to impact on these conservation interests it is recommended that these further studies are carried out prior to works taking place in susceptible drainage channels. It is understood that this may not be possible, with the requirement for ongoing drainage maintenance; however, the potential for direct impacts on fen and whorl snails has been identified in this report. It is recommended that these potential impacts are addressed in consultation with the NPWS in order to ensure compliance of drainage maintenance operations with the requirements of the EC (Natural Habitats) Regulations 1997.

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APPENDIX 1 DESCRIPTIONS OF AFFECTED SACS

The full site synopses of the following SACs are provided on the NPWS website www.npws.ie. Short summary descriptions of these SACs are also provided below.

Lough Corrib (Site Code 000297)

Lough Corrib is situated to the north of Galway city and is the second largest lake in Ireland with an area of approximately 18,240 ha (the entire site is 20,556 ha). The lake can be divided into two parts: a relatively shallow basin, underlain by Carboniferous limestone, in the south and a larger, deeper basin, underlain by more acidic granite, schists, shales and sandstones, to the north.

This site is of major conservation importance and includes 14 habitats listed on Annex I of the E.U. Habitats Directive. Six of these are priority habitats - *Cladium* fen, petrifying springs, active raised bog, limestone pavement, bog woodland and orchid-rich calcareous grassland. The other annexed habitats present include alkaline fens, hard water lakes, lowland oligotrophic lakes, floating river vegetation, degraded raised bogs, Rhynchosporion vegetation, *Molinia* meadows and old Oak woodlands.

Large areas of reedswamp vegetation, dominated by varying mixtures of Common Reed (*Phragmites australis*) and Common Club-rush (*Scirpus lacustris*), occur around the margins of Lough Corrib. Reedswamp usually grades into species-rich marsh vegetation characterised by Slender Sedge (*Carex lasiocarpa*), Water Mint (*Mentha aquatica*), Water Horsetail (*Equisetum fluviatile*) and Bog Bean (*Menyanthes trifoliata*). There are also extensive beds of Saw Sedge (*Cladium mariscus*) that have developed over the marly peat deposits in sheltered bays, particularly in the south-east corner of the lake (NPWS synopsis).

Alkaline fen vegetation is more widespread around the lake margins and includes, amongst the typically diverse range of plants, the Slender Cottongrass (*Eriophorum gracile*), a species protected under the Flora (Protection) Order, 1999. Lough Corrib (site number 000297), is a site designated for fourteen Annex I habitats which include 'Alkaline fen' and 'Calcareous fens with *Cladium mariscus* and species of the *Caricion davallianae*'.

Tory Hill (Site Code 000439)

Tory Hill is an isolated wooded limestone hill situated about 2 km North East of Croom, Co. Limerick. It represents an important feature of the surrounding countryside and is a prime example of a limestone hill set amongst a region of volcanic intrusions of differing shape and geology. The hill is of geomorphological interest for the endmoraine, left by retreating ice, on its northern flanks and for ice-marks that are clearly visible on the solid rock. The site includes Lough Nagirra and its associated wetland vegetation, located to the north and north-east of Tory Hill.

Lough Nagirra has a thick fringe of Common Reed (*Phragmites australis*) and, in association with it, areas of alkaline fen and calcareous fen vegetation referable to the *Caricion davallianae* alliance with Saw Sedge (*Cladium mariscus*). Both of these fen types are listed on Annex I of the E.U. Habitats Directive, the latter with priority status. Tory Hill is also designated for areas of orchid-rich calcareous grassland, a habitat that is listed with priority status on Annex I of the E.U. Habitats Directive; it is found on the eastern side of the hill and

on its summit (NPWS synopsis). Tory Hill (site 000439) is designated for three Annex I habitats which include 'Alkaline fen' and 'Calcareous fens with *Cladium mariscus* and species of the *Caricion davallianae*'.

Lough Ree (Site Code 000440)

Lough Ree is the third largest lake in the Republic of Ireland and is situated, in an ice-deepened depression in Carboniferous Limestone, on the River Shannon system between Lanesborough and Athlone. Some of its features (including the islands) are based on glacial drift. It has a very long, indented shoreline and hence has many sheltered bays. Although the main habitat, by area, is the lake itself, interesting shoreline, terrestrial and semi-aquatic habitats also occur.

Single-species 'swamps' consisting of such species as Common Club-rush (*Scirpus lacustris*), Slender Sedge (*Carex lasiocarpa*), Saw Sedge (*Cladium mariscus*) and two scarce species of Sedge (*Carex appropinquata* and *C. elata*) occur in suitable places in this SAC. Some of these grade up into species-rich calcareous fen with Black Bog-rush (*Schoenus nigricans*) and Whorl-grass (*Catabrosa aquatica*); or freshwater marsh with abundant Water Dock (*Rumex hydrolapathum*) and Hemp-agrimony (*Eupatorium cannabinum*). Lough Ree (site 000440) is designated for seven Annex I habitats and one Annex II species which include 'Alkaline fen'.

Killala Bay /Moy Estuary (Site Code 00458)

The River Moy flows to the sea via a long, narrow estuarine channel north of Ballina town. After approximately 8 km, the estuary widens to form a north-facing triangular bay, with the towns of Inishcrone (Co. Sligo) and Killala (Co. Mayo) situated on the eastern and western shores, respectively.

The rare snail *Vertigo angustior* has been known at this site for over 100 years. It occurs in an area of wet marsh and this site represents one of the few remaining examples of *Vertigo angustior* in its marsh "phase". This species is listed on Annex II of the EU Habitats Directive as it is considered vulnerable in Europe and has been declining throughout much of its range due to loss of habitat, in particular, drainage of wetlands (NPWS synopsis). A previous study of this SAC was found to have a favourable extent of optimal habitat for *Vertigo angustior* (Moorkens 2007a). Killala Bay/Moy Estuary (site 000458) is designated for nine Annex I habitats and for two Annex II species one of which is the whorl snail *Vertigo angustior*.

Charleville Wood (Site Code 000571)

Charleville Wood is a large Oak woodland surrounded by estate parkland and agricultural grassland, located about 3 km south-west of Tullamore. The site, which is underlain by deep glacial deposits, includes a small lake with a wooded island, and a stream runs along the western perimeter. The woodland is considered to be one of very few ancient woodlands remaining in Ireland, with some parts undisturbed for at least 200 years.

The site is notable for the presence of a large population of the rare snail species, *Vertigo moulinsiana*. Extensive swamps of Bulrush (*Typha latifolia*) and Bottle Sedge (*Carex rostrata*) have developed in the lake shallows. Old Oak woodland is a habitat listed on Annex I of the EU Habitats Directive, while the rare snail species, *Vertigo moulinsiana*, is listed on Annex II of this directive (NPWS site synopsis). A previous study of this SAC was found to have a favourable extent of optimal habitat for *Vertigo moulinsiana* (Moorkens 2007a). Charleville

Wood (site 000571) is designated for 9 Annex I habitats and two Annex II species one of which is the whorl snail *Vertigo moulinsiana*.

Bunduff Lough and Machair/ Trawalua/ Mullaghmore (Site Code 000625)

This site is situated on the south side of Donegal Bay, 5 km south-west of Bundoran. The part of the site west of Mullaghmore Head is very exposed to the prevailing wind and swells from the Atlantic, whereas the Head itself affords moderate shelter to the eastern part of the site. The underlying geology is of sedimentary rocks including limestone, shale and sandstone. Windblown sand is common in places, covering much of the underlying rocks and shingle.

Large areas are considered to be transitional to alkaline fen an Annex I habitat. The plant species indicative of fen conditions include Bog Pimpernel (*Anagallis tenella*), Flea Sedge (*Carex pulicaris*), Common Sedge (*Carex nigra*), Marsh Pennywort (*Hydrocotyle vulgaris*), Knotted Pearlwort (*Sagina nodosa*), Common Twayblade (*Listera ovata*), Ragged Robin (*Lychnis flos-cuculi*) and Lesser Spearwort (*Ranunculus flammula*). The fen vegetation is best developed to the south-west of the Bunduff Lough. In addition to the species already mentioned, notable fen species which occur include Grass-of parnassis (*Parnassia palustris*), Common Spotted Orchid (*Dactylorhiza fuchsii*) and the spectacular Marsh Helleborine (*Epipactis palustris*). Moss cover is well developed, frequently attaining 90% cover. Typical species include *Campylium stellatum*, *Drepanocladus revolvens*, *Ctenidium molluscum*, *Calliergon cuspidatum* and *Philonotis fontana*, most of which indicate the presence of wet, base-rich conditions. These areas of wet machair/alkaline fen are very species-rich, often containing 40-50 plant species in an area of 4m². Bunduff Lough and Machair/ Trawalua/ Mullaghmore (site 000625) is designated for nine Annex I habitats and one Annex II species.

Ryewater Valley

This site is located between Leixlip and Maynooth. It extends along the Rye Water, a tributary of the River Liffey. The Rye Water in Carton Estate is dammed at intervals, creating a series of lakes.

The marsh, mineral spring and seepage area found at Louisa Bridge supports a good diversity of plant species, including Stoneworts, Arrowgrass (*Triglochin palustris*), Purple Moor-grass (*Molinea caerulea*), Sedges (*Carex* spp.), Common Butterwort (*Pinguicula vulgaris*), Marsh Lousewort (*Pedicularis palustris*), Grass-of-parnassus (*Parnassia palustris*) and Cuckooflower (*Cardamine pratensis*). The mineral spring found at the site is of a type considered to be rare in Europe and is a habitat listed on Annex I of the EU Habitats Directive. The semi-aquatic snails *Vertigo angustior* and *V. moulinsiana* occur in marsh vegetation near Louisa Bridge; both are rare in Ireland and Europe and are listed on Annex II of the EU Habitats Directive. The main importance of the site lies in the presence of several rare and threatened plant and animal species, and of a rare habitat, thermal, mineral, petrifying spring. A previous study of this SAC was found to have an unfavourable extent of optimal habitat for *Vertigo angustior*. It was found to be dry and limited in 2006 (Moorkens 2007a). The Ryewater valley (site 001398) is designated for one Annex I habitats and two Annex II species: the whorl snails *Vertigo moulinsiana* and *Vertigo angustior*. This site was not surveyed in the preparation of this report.

Urlaur Lakes

This site comprises three small hard water lakes, a habitat listed on Annex I of the EU Habitats Directive. The lakes - Lough Nanoge, Lough Roe and Urlaur Lough - lie in the Upper catchment of the Lung River, a major tributary of the Boyle River. The site is located approximately 10 km north of Ballyhaunis in Co. Mayo. Swamps and reedbeds fringe the open water of the three lakes in places. These are generally dominated by Common Club-rush (*Scirpus lacustris* subsp. *lacustris*) with occasional Saw Sedge (*Cladium mariscus*), Water Horsetail (*Equisetum fluviatile*) and Bogbean (*Menyanthes trifoliata*). At the western end of Lough Roe is an extensive quaking area of swamp vegetation. Bulrush (*Typha latifolia*), Common Reed (*Phragmites australis*) and Ragged Robin (*Lychnis flos-cuculi*) are common here and willows (*Salix* sp.) are colonising in places.

The shorelines consist of shallow mineral soils with flush vegetation dominated by Black Bog-rush (*Schoenus nigricans*). In most cases, this is backed by agricultural grassland. Elsewhere the shoreline is peaty and is backed by cutaway bog or flush/marsh vegetation. Ling Heather (*Calluna vulgaris*), Purple Moor-grass (*Molinia caerulea*) and Royal Fern (*Osmunda regalis*) are abundant on the cutaway. In some places there is flushed, species-rich heath with Lesser Butterfly-orchid (*Platanthera bifolia*), Pyramidal Orchid (*Anacamptis pyramidalis*), Heath Spotted-orchid (*Dactylorhiza maculata*), Meadow Thistle (*Cirsium dissectum*), Quaking-grass (*Briza media*) and Bog-myrtle (*Myrica gale*). Urlaur Lakes SAC (site 001571) is designated for three Annex I habitats, one of which is Alkaline fen. This site was not surveyed in the preparation of this report.

Lough Ennell (Site Code 000625)

Lough Ennell is a large, open, steep-sided lake, located 3km south of Mullingar, Co. Westmeath. The lake bottom is of limestone with a marl deposit. The water is markedly alkaline and mesotrophic, possibly owing to effluents received from Mullingar town and to fertilizer inputs from farmland surrounding the lake. The River Brosna flows into the lake from the north, at Butler's Bridge, and out from the south.

Alkaline fen, a habitat listed on Annex I of the EU Habitats Directive, is also found on the lake shore with species such as Grass-of-parnassus (*Parnassia palustris*), Marsh Pennywort (*Hydrocotyle vulgaris*) and Bottle Sedge (*Carex rostrata*). In wet marshy patches along the shore Marsh-marigold (*Caltha palustris*), Brookweed (*Samolus valerandi*) and Lesser Water-plantain (*Baldellia ranunculoides*) are common. Reedbeds and species-poor swamp vegetation occasionally fringe the lake, particularly around the points of inflow and outflow and on the eastern shore, around Tudenham Park. Common Reed (*Phragmites australis*) is abundant here. Waterplantain (*Alisma plantago-aquatica*), Cowbane (*Cicuta virosa*), Frogbit (*Hydrocharis morsus-ranae*) and Tufted Sedge (*Carex elata*) also occur. The latter two species are of note in that they are of occasional in the eastern midlands but are rarely recorded elsewhere. The rare Fibrous Tussock-sedge (*Carex appropinquata*) has been recorded here also.

Lough Owel (Site Code 000688)

Lough Owel is a large hard water lake, a habitat listed on Annex I of the EU Habitats Directive. The lake is located approximately 4km north-west of Mullingar. It is a relatively shallow lake with a rocky, marl-covered bottom.

There are, however, areas of marsh and fen in the northern and south-western corners of the lake. These areas (Bunbrosna marsh and Tullaghan fen) were formerly separate Areas of Scientific Interest but have now been included within the Lough Owel site. Bunbrosna is an area of marsh and fen which is partially invaded by Downy Birch (*Betula pubescens*) and Willows (*Salix* spp.). The area contains some rare plant species, namely Marsh Pea (*Lathyrus palustris*), Marsh Fern (*Thelypteris palustris*) and the protected Round-leaved Wintergreen (*Pyrola rotundifolia*). In addition, four other rare plant species are found along the lake margins namely, White Sedge (*Carex curta*), Fibrous Tussock-sedge (*Carex appropinquata*), Marsh Stitchwort (*Stellaria palustris*) and Frogbit (*Hydrocharis morsus-ranae*). Tullaghan fen is an area of flooded cut-over bog which has developed a varied fen and marsh vegetation quite similar to Bunbrosna marsh. Bog-sedge (*Carex limosa*), Tussock-sedge and Marsh Fern are to be found here. With the exception of Lough Carra in County Mayo, Lough Owel is the best example of a large, spring-fed calcareous lake in the country. The site is of major conservation significance, containing, as it does, three habitats that are listed on Annex I of the EU Habitats Directive, i.e. alkaline fens, transition mires and hard water lakes. Lough Owel (site 000688) is designated for three Annex I habitats.

Clonaslee Eskers and Derry Bog (Site Code 000859)

Located approximately 5km west of the town of Clonaslee, this site consists of a series of morainic hills and esker ridges which are the legacy of the last period of glaciation. To the north-west the Derry Hills are two isolated hills situated in a bog, which forms part of the site. The main esker ridge runs along the southern part of the site. To the east of the site water percolates down through the glacial material of the esker ridge and emerges in a series of small, calcium-rich springs which flow into cutaway bog to the north. This results in the creation of a species-rich alkaline fen, a habitat that is listed on Annex I of the E.U. Habitats Directive. Black Bog-rush (*Schoenus nigricans*) dominates the vegetation here. Also present are Pale Butterwort (*Pinguicula lusitanica*), Meadow Thistle (*Cirsium dissectum*), Round-leaved Sundew (*Drosera rotundifolia*) and the distinctive Fly Orchid (*Ophrys insectifera*). The latter species is confined to parts of the west and Midlands, where it occurs only occasionally. Derry Bog, which is a cutaway raised bog, lies to the north-west of the site. This supports a typical range of bog mosses and flowering plants, such as Ling Heather and Bog Asphodel (*Narthecium ossifragum*).

The rare snail *Vertigo geyeri* was recorded from the fen area at this site in 1998. This species is a glacial relic with a disjunct European population, which is considered vulnerable due to loss of habitat, particularly through drainage. It is listed on Annex II of the E.U. Habitats Directive (NPWS site synopsis). A previous study of this SAC was found to have an unfavourable extent of optimal habitat for *Vertigo geyeri* (Moorkens 2007a).

This site is of conservation importance for the presence of alkaline fen vegetation and is considered one of the best sites in the south-east region for this habitat. Also of interest is the extremely unusual assemblage of plants associated with the esker ridges, which includes three rare plants, two of which are legally protected in Ireland. Of further conservation importance is the presence of the rare snail *Vertigo geyeri*. Clonaslee Eskers and Derry Bog SAC (site 000859) is designated for two Annex I habitats, one of which is Alkaline fen. It is also designated for one Annex II species, *Vertigo geyeri*.

Ross Lake & Woods (Site Code 001312)

Ross Lake and Woods is located approximately 4 km north-west of Moycullen on the west side of Lough Corrib in Co. Galway. The area is underlain by limestone. The main habitat on the site is a medium-sized lake, Ross Lake, which has a limestone bed covered by deposits of precipitated marl and a shoreline of marl-encrusted limestone boulders.

Most of the shoreline is fringed by wetland vegetation of reedswamp, freshwater marsh, fen, wet woodland and wet grassland. Reedswamp vegetation is dominated by Common Reed (*Phragmites australis*) and Common Club-rush (*Scirpus lacustris*), with Great Fen-sedge (*Cladium mariscus*) also occurring. The rocky limestone shore mostly supports fen-type vegetation characterised by Black Bog-rush (*Schoenus nigricans*). This grades into areas of wet grassland dominated by Purple Moor-grass (*Molinia caerulea*) and species-rich marsh, characterised by species such as Slender Sedge (*Carex lasiocarpa*), Marsh Pennywort (*Hydrocotyle vulgaris*) and Water Mint (*Mentha aquatica*). Ross lakes and woods SAC (site 001312) is designated for four Annex I habitats, one of which is Alkaline fen and for two Annex II species.

Lough Carra/ Mask Complex (Site Code 001774)

This site is dominated by two large lakes, Lough Mask and Lough Carra, and includes the smaller Cloon Lough. On the western side, the site is overlooked by the Partry Mountains, while to the east the landscape is largely low-lying agricultural land. The nearest large town is Ballinrobe which is about 4 km east of Lough Mask. The general geological character of the area is Carboniferous limestone, with some shales and sandstones on the western side of Lough Mask. The underlying geology results in a great diversity of habitats, which support many scarce and rare plants and animals. A wide range of wetland habitats occur around Lough Carra and along parts of the eastern and southern shores of Lough Mask, including *Cladium* fen and alkaline fen, both listed as Annex I habitats on the EU Habitats Directive. The *Cladium* occurs as pure stands in places but also intermixed with Black Bog-rush (*Schoenus nigricans*), Common Club-rush (*Scirpus lacustris*), Common Reed (*Phragmites australis*) and a number of sedge species (*Carex* spp.).

The alkaline fens are more extensive than the *Cladium* fens and here Black Bog-rush is a dominant species. A rich diversity of flowering plant occurs in the fen communities. In addition to the fen habitats, there are sparse but widespread reed swamps, wet grassland and some freshwater marsh communities around the lake shores. Lough Carra/ Mask Complex (site 001774) is designated for eight Annex I habitats and three Annex II species.

River Barrow & River Nore (Site Code 002162)

This site consists of the freshwater stretches of the Barrow/Nore River catchments as far upstream as the Slieve Bloom Mountains and it also includes the tidal elements and estuary as far downstream as Creadun Head in Waterford. The site passes through eight counties – Offaly, Kildare, Laois, Carlow, Kilkenny, Tipperary, Wexford and Waterford. The Nore, for a large part of its course, traverses limestone plains and then Old Red Sandstone for a short stretch below Thomastown. Before joining the Barrow it runs over intrusive rocks poor in silica. The upper reaches of the Barrow also runs through limestone. The middle reaches and many of the eastern tributaries, sourced in the Blackstairs Mountains, run through Leinster Granite. The southern end, like the Nore runs over intrusive rocks poor in silica. Waterford Harbour is a deep valley excavated by glacial floodwaters when the sea level was lower than

today. The coast shelves quite rapidly along much of the shore. A previous study of this SAC was found to have an unfavourable extent of optimal habitat for *Vertigo moulinsiana* (Moorkens 2007a). River Barrow and River Nore (site 002162) is designated for twelve Annex I habitats and twelve Annex II species both of which are whorl snails *Vertigo moulinsiana* and *Vertigo angustior*.

Lough Derg, North East Shore (Site Code 002241)

Lough Derg, the lowest order lake on the River Shannon, is one of the largest bodies of freshwater in Ireland. The site, however, only includes the northern shore of the lake from the mouth of the Cappagh River in the north-west to just below Black Lough at the north-eastern shore. The greater part of this site lies on Carboniferous limestone, although there is Old Red Sandstone on the southern shores of the eastern section. The site is of significant ecological interest, with six habitats listed on Annex I of the E.U. Habitats Directive. Four of these are priority habitats - *Cladium* fen, alluvial woodland, limestone pavement and Yew woodland. Other annexed habitats present include alkaline fen and Juniper scrub formations on heath and calcareous grasslands.

The priority Annex I habitat, *Cladium* fen occurs occasionally along the lake margins, mainly in association with alkaline fens, Common Reed (*Phragmites australis*) and other swamp vegetation. Typically Saw Sedge (*Cladium mariscus*) forms dense stands up to 2 m in height. Associated species include Common Reed, Black Bogrush (*Schoenus nigricans*), Water Horsetail (*Equisetum fluviatile*) Bottle Sedge (*Carex rostrata*) and occasional Slender Sedge (*Carex lasiocarpa*). This community generally merges with alkaline fen dominated by Black Bog-rush with Purple Moorgrass (*Molinia caerulea*), Marsh Horsetail (*Equisetum palustre*), Meadowsweet (*Filipendula ulmaria*) and scattered tussocks of Greater Tussock-sedge (*Carex paniculata*). Lough Derg, North East Shore (site 002241) is designated for six Annex I habitats.

Carrowmore Dunes (Site Code 002250)

This SAC is designated for containing *Vertigo angustior* (NPWS website). Carrowmore Dunes are situated on the south-western coast of County Clare, roughly midway between Milltown Malbay and Kilkee, and extends from Carrowmore Point in the north to Doonbeg Bay in the south. Fine sandy beach merges into a cobble beach on the seaward side of a sand dune system. Exposed bedrock marks the northern and southern boundaries of the site. Seaward, the site extends for 500m from the shore to include shallow marine waters. The geology of the site comprises Upper Carboniferous sandstone and shale. Pure sand dominates the soils on the seaward side, with increasing organic content further inland. Carrowmore Dunes (site 002250) is designated for four Annex I habitats and one Annex II species, *Vertigo angustior*.

Askeaton Fen Complex (Site Code 002279)

Askeaton Fen Complex consists of a number of small fen areas to the east and south east of Askeaton in Co. Limerick. This area of undulating hills, some of which are quite steep, is underlain by Lower Carboniferous Limestone. At the base of the hills a series of fens/reedbeds/loughs can be found, more often than not, in association with marl or peat deposits. At the south east of Askeaton, both Cappagh and Ballymorisheen fens are surrounded by large cliff-like rocky limestone outcrops.

The site is a candidate SAC selected for *Cladium* fen and also for alkaline fen, both habitats listed on Annex I of the E.U. Habitats Directive. At this site a diversity of fen types are represented in a graduation from open water to drier seepage areas. Most importantly the fen type represented by Saw Sedge (*Cladium mariscus*) occurs in various forms. It is the dominant fen type present. It is associated with wet conditions generally not > 25 cm deep and can be found in mono-dominant stands growing on a marl base such as at Feereagh and Mornane Loughs and in the fen in the townland of Mornane. It can also be co-dominant with Common Reed (*Phragmites australis*) in slightly drier conditions such as in Deegerty, Blind Lough and Dromlohan. It is also found in association with alkaline fen species such as Black Bog-rush (*Schoenus nigricans*) where it grows on a peaty substrate.

Saw Sedge fen is indicative of extremely base rich conditions. Typical species seen growing with the Saw Sedge include Pondweeds (*Potamogeton* spp.), Marsh Horsetail (*Equisetum palustre*), Water Horsetail (*E. fluviatile*), Lesser Water-parsnip (*Berula erecta*), Lesser Marshwort (*Apium innundatum*), Bottle Sedge (*Carex rostrata*), particularly where marl is present, and Water Mint (*Mentha aquatica*). One such area of fen within the site is the only known location in Ireland for the water beetle *Hygrotus decoratus* and is also known to contain *Hydroporus scalesianus*, a rare water beetle indicative of undisturbed fens. At the edge of some of the Saw Sedge fens, particularly where improved grassland is not present, there is typically found a gradation to wet marsh in turn grading to wet grassland. This transition habitat adds to the ecological diversity of the site.

Alkaline fen is characterised by the presence of Black Bog-rush in association with brown mosses and the small sedge community. The soil is permanently waterlogged but generally not flooded unless for a short period. Examples of this fen type are found at the edge of almost all the sites but its extent is much less than the Saw Sedge fen type. The fen in the townlands of Moig West and Graigues is a good example. Species seen growing with Black Bog-rush include; Purple Moor-grass (*Molinia caerulea*), Long-stalked Yellow Sedge (*Carex lepidocarpa*), Carnation Sedge (*Carex panicea*), Rushes (*Juncus* spp.) and an abundance of brown mosses including *Campylium stellatum*, *Ctenidium molluscum*, *Calliergon cuspidatum* and *Bryum pseudotriquetrum*. This fen type also grades into marsh and wet grassland.

Landuse in the area is quite intensive with improved grassland extending down relatively steep slopes to the edge of the fens/loughs. New drainage in the past and the deepening of existing drains poses a threat to the aquatic habitats at the site. In some instances, as noted above, the fens appear to be drying out. The value of this site is that it supports two fen types each of which exhibit many subtypes. *Cladium* fen is listed as an Annex I priority habitat under the E.U. Habitats Directive. These wetland habitats of fen, reedbeds, open water, marsh and wet grassland are also valuable in that they supply a refuge for fauna in an otherwise intensively managed countryside. Askeaton Fen Complex (site 002279) is designated for four Annex I habitats and one Annex II species, *Vertigo angustior*.

Rivers Boyne & Blackwater (Site Code 002299)

This site comprises the freshwater element of the River Boyne as far as the Boyne Aqueduct, the Blackwater as far as Lough Ramor and the Boyne tributaries including the Deel, Stoneyford and Tremblestown Rivers. These riverine stretches drain a considerable area of Meath and Westmeath and smaller areas of Cavan and Louth. The underlying geology is Carboniferous Limestone for the most part with areas of Upper, Lower and Middle well represented. In the vicinity of Kells Silurian Quartzite is present while close to Trim are

Carboniferous Shales and Sandstones. There are many large towns adjacent to but not within the site. Towns both small and large, include Slane, Navan, Kells, Trim, Athboy and Ballivor.

The site contains alkaline fen, one of the two Annex I habitats for which it was selected. The main areas of alkaline fen are concentrated in the vicinity of Lough Shesk, Freehan Lough and Newtown Lough. The hummocky nature of the local terrain produces frequent springs and seepages which are rich in lime. A series of base-rich marshes have developed in the poorly-drained hollows, generally linked with these three lakes. Open water is usually fringed by Bulrush (*Typha latifolia*), Common Club-rush (*Scirpus lacustris*) or Common Reed (*Phragmites australis*) and this last species also extends shorewards where a dense stand of Saw Sedge (*Cladium mariscus*) frequently occurs. This in turn grades into a sedge and grass community (*Carex* spp., *Molinia caerulea*) or one dominated by the Black Bogrush (*Schoenus nigricans*). An alternative direction for the aquatic/terrestrial transition to take is through a floating layer of vegetation. This is normally based on Bogbean (*Menyanthes trifoliata*) and Marsh cinquefoil (*Potentilla palustris*). Other species gradually become established on this cover, especially plants tolerant of low nutrient status e.g. bog mosses (*Sphagnum* spp.).

Diversity of plant and animal life is high in the fen and the flora, includes many rarities. The plants of interest include Narrow-leaved Marsh Orchid (*Dactylorhiza traunsteineri*), Fen Bedstraw (*Galium uliginosum*), Cowbane (*Cicuta virosa*), Frogbit (*Hydrocharis morsus-ranae*) and Least Bur-reed (*Sparganium minimum*). These species tend to be restricted in their distribution in Ireland. Also notable is the abundance of aquatic Stoneworts (*Chara* spp.) which are characteristic of calcareous wetlands. The rare plant, Round-leaved Wintergreen (*Pyrola rotundifolia*) occurs around Newtown Lough. This species is listed in the Red Data Book and is protected under the Flora Protection Order, 1999, and this site is its only occurrence in Co. Meath. Rivers Boyne and Blackwater SAC (site 002299) is designated for two Annex I habitats and for three Annex II species.

River Finn (Site Code 002301)

This site comprises almost the entire freshwater element of the Finn and its tributaries – the Corlacky, the Reelan sub-catchment, the Sruhamboy, Elatagh, Cummirk and Glashagh, and also includes Lough Finn, where the river rises. The spawning grounds at the headwaters of the Mourne and Derg Rivers, Loughs Derg and Belshade and the tidal stretch of the Foyle north of Lifford to the border are also part of the site. The Finn and Reelan, rising in the Bluestack Mountains, drain a catchment area of 195 square miles. All of the site is in Co. Donegal. The site is a candidate SAC selected for active blanket bog, a priority habitat listed under Annex I of the E.U. Habitats Directive. The site is also listed for lowland oligotrophic lakes, wet heath and transition mires, also on Annex I of the E.U. Habitats Directive.

Transition mires or quaking bogs or scraws occur at several locations, usually at the interface between bog or lake or stream. In Owendoo/Cloghervaddy there are many examples of small lakes south of Belshade. Some of the lakes contain floating scraws of the bog moss (*Sphagnum recurvum*), Bottle Sedge (*Carex rostrata*), Mud Sedge (*Carex limosa*) and Bogbean (*Menyanthes trifoliata*). West of Owendoo River there is an extensive area of scraw with a similar suite of species but with a different abundance. Quaking areas are also associated with blanket bog at Cronamuck and Cronakerny. At Cronamuck, a small level flushed area occurs at the base of a slope leading into a flushed stream. Diversity including diagnostic species is good. River Finn SAC (site 002301) is designated for four Annex I habitats and for two Annex II species.

Ballymore Fen (Site Code 002313)

Ballymore Fen lies approximately 17 km west of Mullingar adjacent to the Mullingar to Ballymore road (R390) in Co. Westmeath. The geology of the area is Carboniferous Limestone. The site occupies a relatively wide and deep depression in the surrounding drift which is fed on both the east and west by springs. The area may at one stage have been a lake of some size but at present is occupied by a transition mire complex with the characteristic lagg fen at the edges. In the wetter areas towards the centre and south of the site the vegetation is characterised by a scraw typified by patches with an abundance of Bogbean (*Menyanthes trifoliata*) and Water Horsetail (*Equisetum fluviatile*). Other associated plants include Marsh Helleborine (*Epipactis palustris*), Water Mint (*Mentha aquatica*), Marsh Cinquefoil (*Potentilla palustris*), Marsh Bedstraw (*Galium palustre*), Angelica (*Angelica sylvestris*), Lesser Spearwort (*Ranunculus flammula*) and sedges (*Carex* spp.). In slightly drier areas and on old banks are Willow (*Salix*) saplings, with occasional Ash (*Fraxinus excelsior*) and ferns such as Regal Fern (*Osmunda regalis*) and Broad Buckler-fern (*Dryopteris dilatata*). Where there is flowing water Lesser Water-parsnip (*Berula erecta*) is present.

At the edge of the wetter area, particularly at the east of the site, is a gradation to Black Bog-rush (*Schoenus nigricans*) dominated fen area. Throughout are Willow saplings with some Purple Moor-grass (*Molinia caerulea*) and bog moss hummocks (*Sphagnum* spp.). Between the hummocks, abundant Round-leaved Wintergreen (*Pyrola rotundifolia*) - a Red Data Book Species, occurs with species typically found in such conditions. The bryophyte communities are of considerable interest.

Curraghchase Woods SAC (Site Code 00432)

This site is situated approximately 7 km east of Askeaton in County Limerick. The area is characterised by glacial drift deposits over Carboniferous limestone. The site consists largely of mixed woodland and a series of wetlands. The main interest, however, is the presence of a hibernation site of the Lesser Horseshoe Bat (*Rhinolophus hipposideros*), a species listed on Annex II of the EU Habitats Directive. This is the largest known site for this species in County Limerick.

The woodland consists of both deciduous species and stands of commercial conifers. A series of small lakes and fens runs the length of the site. Some of these lakes are overgrown with vegetation. These wetlands, along with some wet grassland, add habitat diversity to the site.

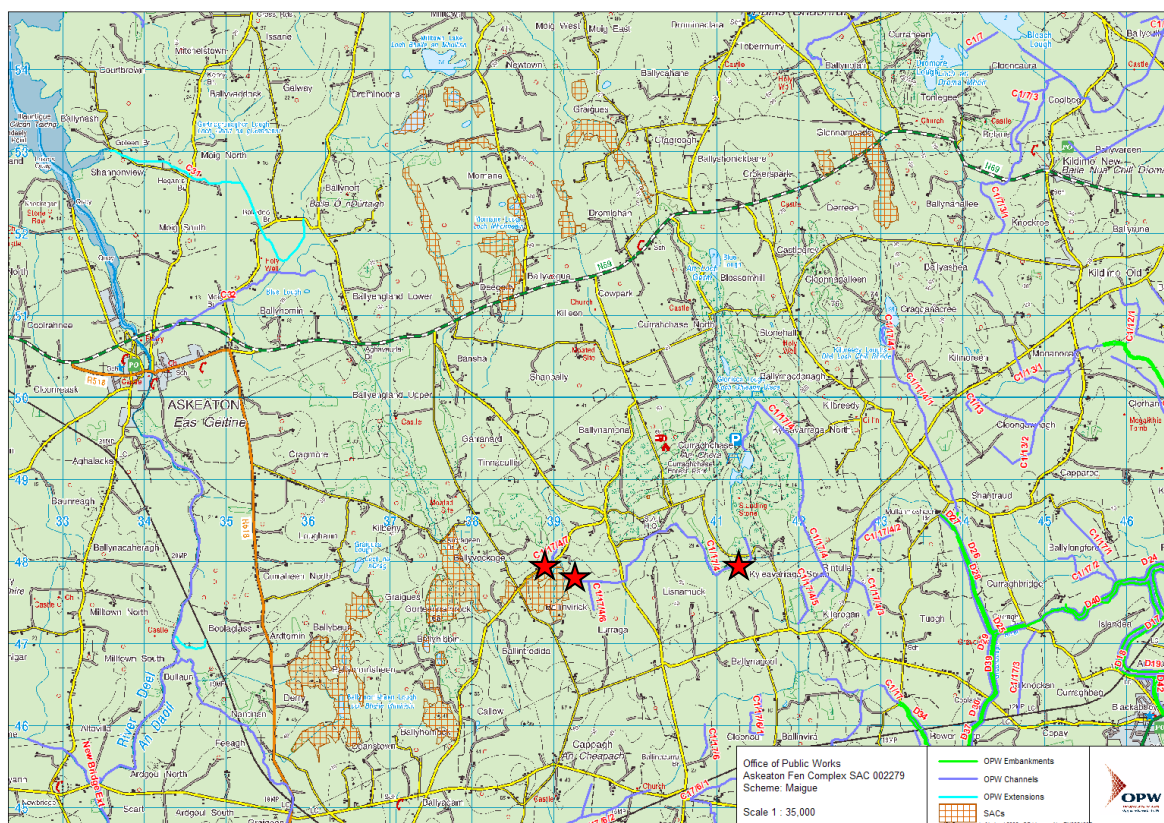
River Moy SAC (Site Code 002298)

This site comprises almost the entire freshwater element of the Moy and its tributaries including both Loughs Conn and Cullin. The system drains a catchment area of 805 sq. km. Most of the site is in Co. Mayo though parts are in west Sligo and north Roscommon. Apart from the Moy itself, other rivers included within the site are the Deel, Bar Deela, Castlehill, Addergoole, Clydagh and Manulla on the west side and the Glenree, Yellow, Strade, Gweestion, Trimogue, Sonnagh, Mullaghanoe, Owengarve, Eighnagh and Owenaher on the east side. The underlying geology is Carboniferous Limestone for the most part though Carboniferous Sandstone is present at the extreme west of the site with Dalradian Quartzites and schists at the south west.

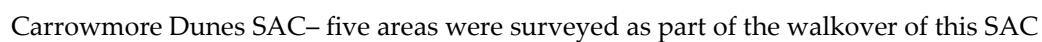
Drainage of the Moy in the 60s lowered the level of the lakes, exposing wide areas of stony shoreline and wet grassland, which are liable to flooding in winter. This increased the habitat diversity of the shoreline and created a number of marginal wetlands, including fens and marshes. A large section of fen habitat is included within the site designation at Island Lake, near Knock, Co. Mayo. This fen contains a significant population of the whorl snail *Vertigo geyeri*. Plant species of note include Heath Cudweed (*Omalotheca sylvatica*), Great Burnet (*Sanguisorba officinalis*) and Irish Lady's-tresses (*Spiranthes romanzoffiana*). These three species are listed on the Irish Red Data list and are protected under the Flora Protection Order 1999. Other habitats present within the site include wet grassland dominated by Rushes (*Juncus* spp.) grading into species-rich marsh in which sedges are common.

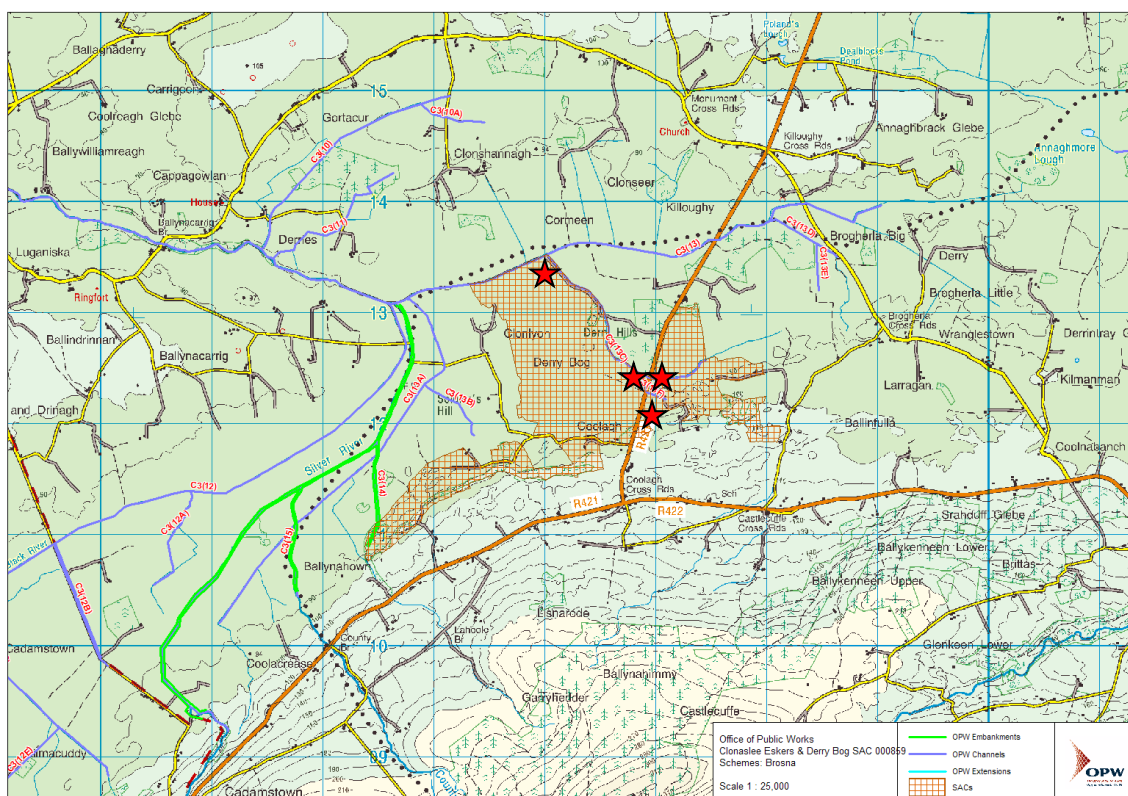
APPENDIX 2 MAPS SHOWING OPW DRAINAGE CHANNELS SURVEYED DURING THE CURRENT ASSESSMENT

The sections of drainage channels surveyed within each SAC site are indicated by a red star (★). Site walkovers at these sections took the form of a linear survey of the channel from this point.

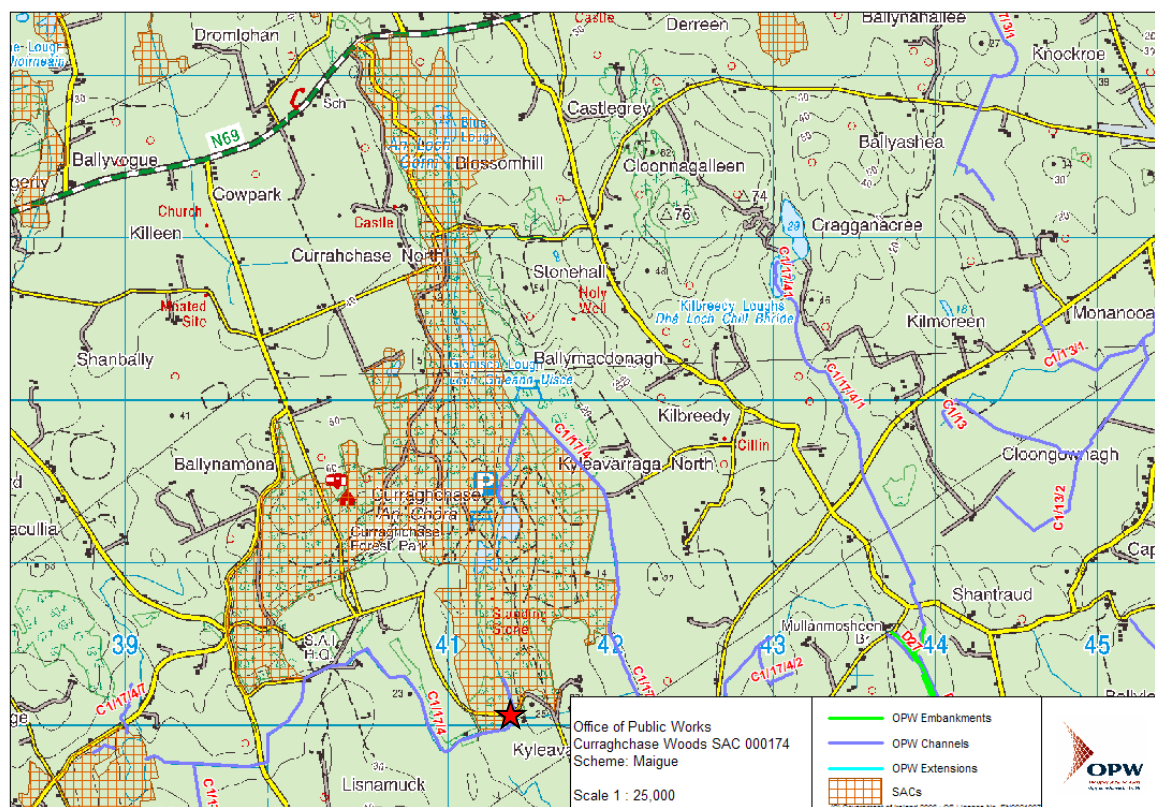


Askeaton Fen Complex SAC – Three areas of the SAC were surveyed during this walkover

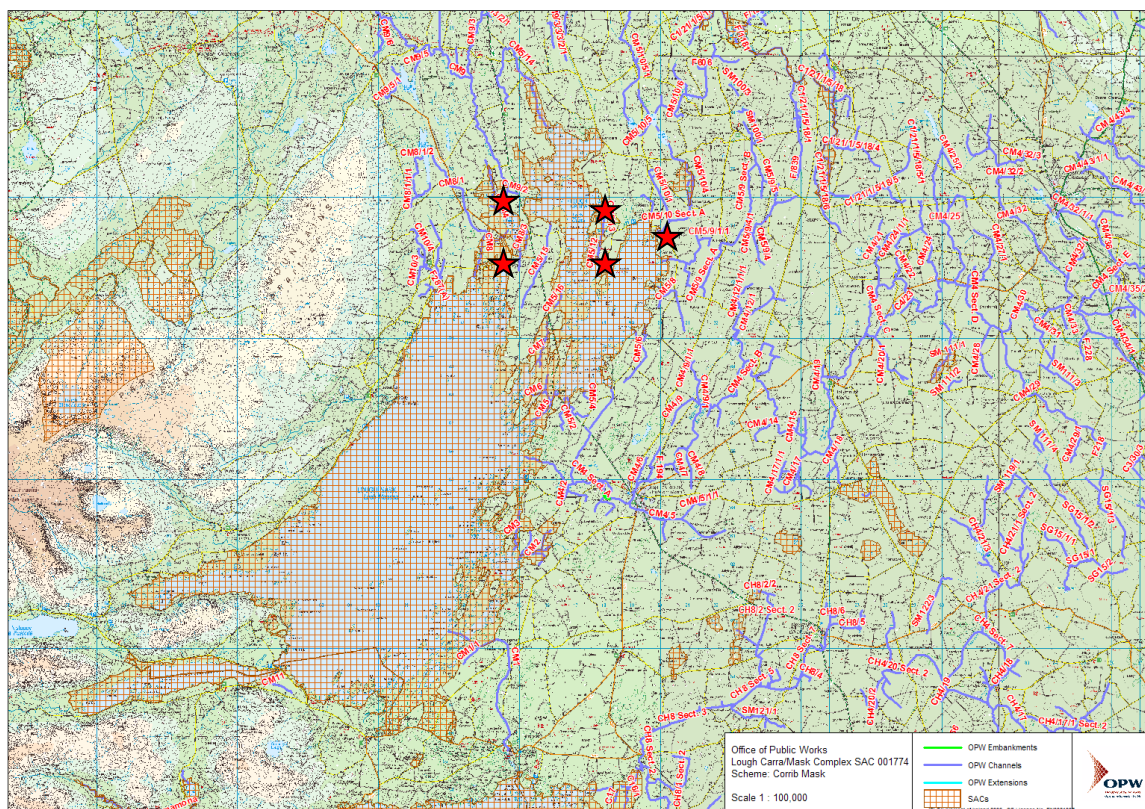




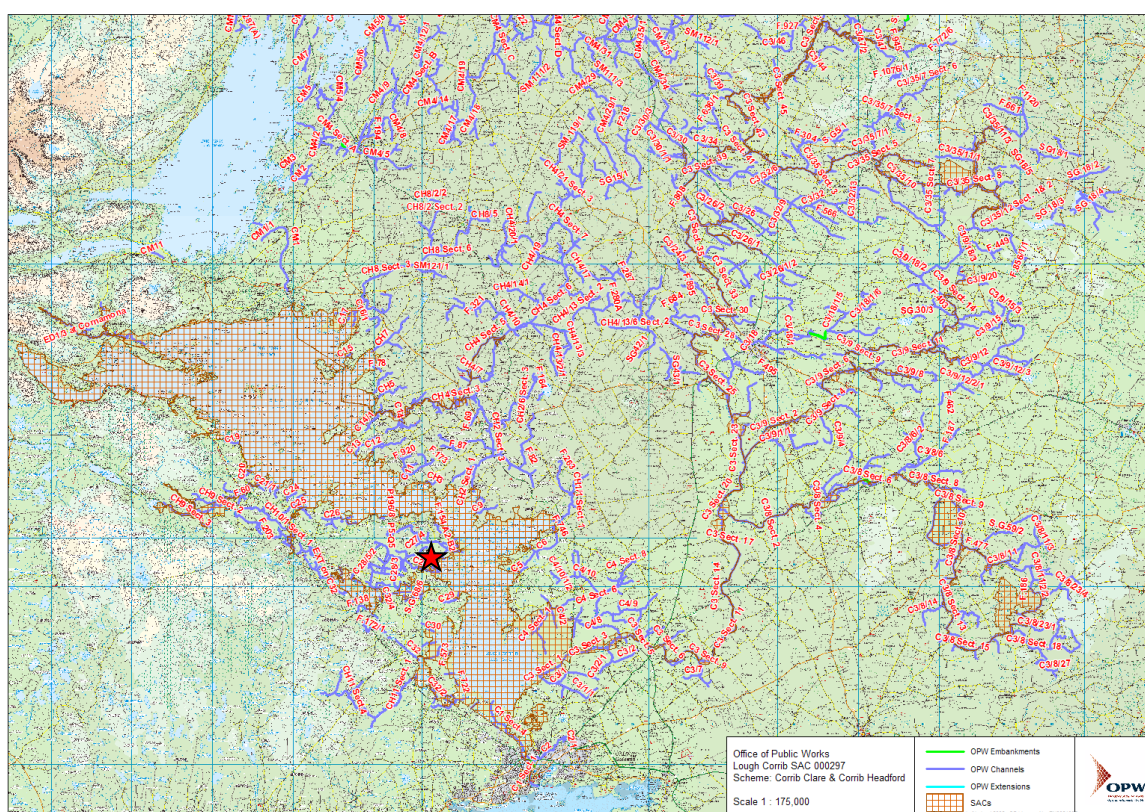
Clonaslee Eskers/Derry Bog SAC – Four areas of this SAC were surveyed as part of this walkover.



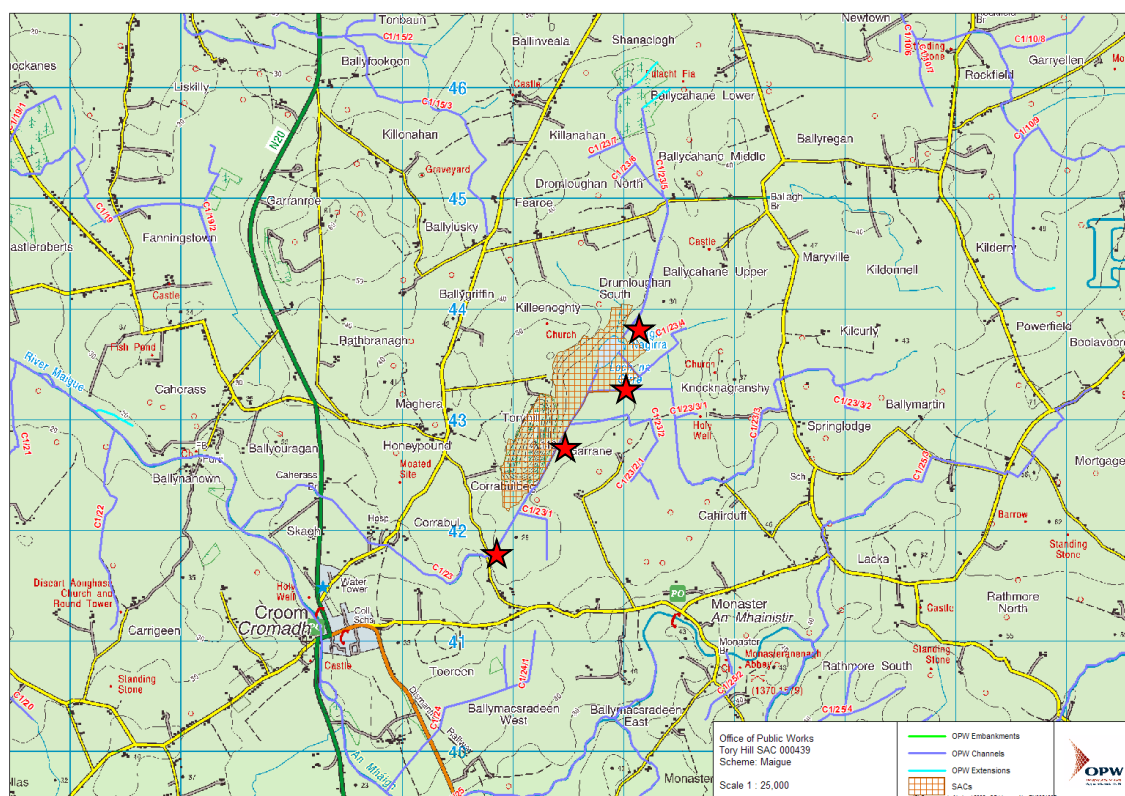
Curraghchase Woods SAC – One portion of this SAC was surveyed during this walkover, due to access restrictions.



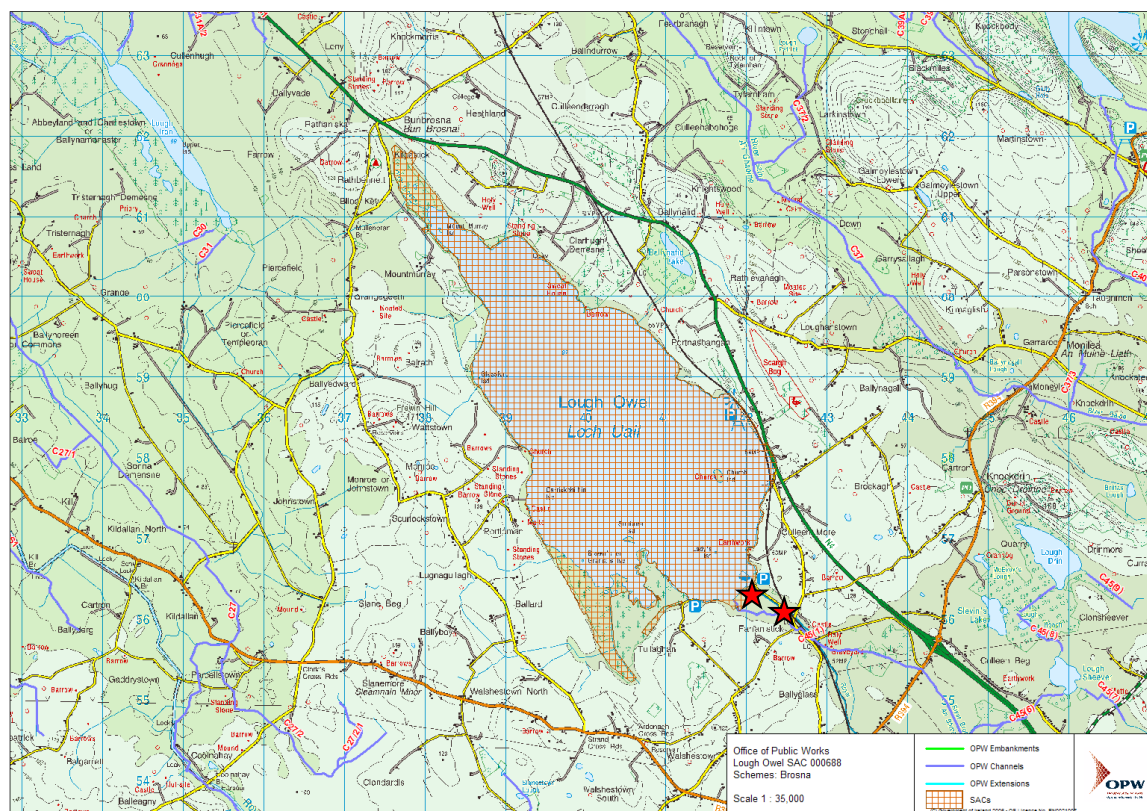
Lough Mask/Lough Carra SAC – Five areas were surveyed during the walkover of this SAC



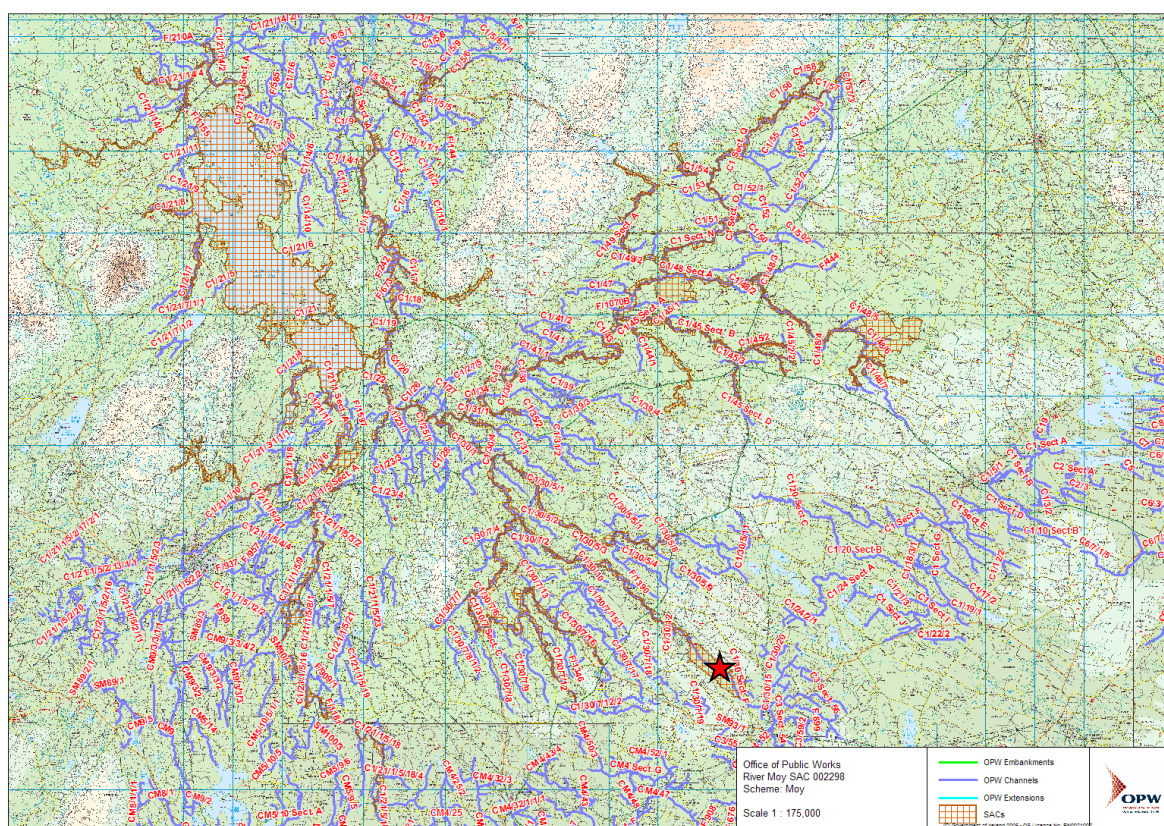
Lough Corrib SAC – one area was surveyed as part of the walkover for this SAC



Tory Hill SAC – four areas were surveyed as part of the walkover in this SAC



Lough Owel SAC – Two areas were surveyed as part of the walkover in this SAC.



River Moy SAC – one area was surveyed as part of the walkover in this SAC