Gearagh Scoping Exercise
Scoping Report

ESB GWM

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Contents

1 Introduction

1.1 Context of Scoping Exercise

The ESB property boundary for Carrigadrohid Reservoir, Co. Cork, incorporates two Natura 2000 sites (one Special Area of Conservation (SAC) and one Special Protection Area (SPA)) associated with 'The Gearagh' at the western extent of the waterbody. One of the main qualifying features of the SAC at The Gearagh is the area of alluvial woodland (a priority habitat) along the Toon River, downstream of Toon Bridge, where it enters probably the best of the very few examples of an anastomosing lowland forested river in north-west Europe; the woodland also extends to the south, along the course of the River Lee. The second Natura 2000 site, The Gearagh Special Protection Area (SPA) overlaps to a large degree with the SAC.

A complaint has been lodged with the European Commission relating to concerns over potential erosion within the alluvial woodland downstream of Toon Bridge at the western extent of the SAC. The complaint relates to whether purported increased spate loads (increased hydrographic peaks) on the Toon River itself are leading to increased levels of bank and riverbed erosion along the Toom River within the alluvial forest, to the detriment of the anastomosing system, and whether this is leading to (a) erosion and loss of islands in the Toon part of the system, and (b) isolation and drying of diversion channels.

A key feature of anastomosis is the occurrence of erosion resistant banks and stable channels (unlike braided rivers). The complaint focuses on whether these are being eroded by human-influenced activities in the Toon River floodplain upstream, and whether future surface drainage for wind-farms, such as the Cleanrath wind-farm (recently granted permission by An Bord Pleanála (PL04.240801) will contribute to this in the future.

Arising from the complaint, the Commission initiated a Pilot Infringement Case against Ireland (Ref: 5450/13). Additionally, a separate petition to the European Parliament was also made by the same complainant (ref: 1056/2013).

The Department of Arts Heritage and the Gaeltacht submitted a written response to the Commission, with input from the Department of Environment, Community and Local Government and Cork County Council in April 2015. This response concluded that the best course of action would be to form a small working group to consider whether there would be merit in having further analysis carried out with a view to developing the potential of the area as a nature reserve, conservation demonstration project and tourism asset.

A provisional site visit along the affected stretch of the Toon River was carried out by representatives of the Department of the Environment, Community and Local Government (DECLG) and National Parks and Wildlife Services (NPWS – which is under the aegis of the Department of Arts Heritage and the Gaeltacht) on the 15th April 2015. Arising from this visit, the DECLG representative noted that "*causality between the evolution of local land use patterns and what may or may not be happening to the catchment cannot be proven on the basis of the evidence presented* *by [the complainant]*". The NPWS representative recommended that a fluvial geomorphological assessment of possible changes in the Toon River part of The Gearagh system be carried out. A copy of the report of DECLG and NPWS following the site visit is enclosed in Appendix 5.

As previously described, a separate petition to the European Parliament was made by the same complainant (ref: 1056/2013), who directly addressed the EP Petitions Committee on September 8th 2016. A European Commission representative also addressed the Committee, noting the engagement undertaken by the Commission with the Irish Government to date.

As part of an initial response to the Commission case, the Department of Housing, Planning and Local Government (DHPCLG, formerly DECLG) convened a working group of key stakeholders for The Gearagh site, comprising representatives from DHPCLG, Cork County Council, NPWS and ESB/ESB International.

This group held a meeting on June 7th 2016 to discuss next steps and outline deliverables relating to the provision of a response to the Commission and also to assess constraints and options for the long-term management of The Gearagh woodland.

Arising from this meeting, it was agreed that to facilitate the above, an initial scoping exercise was required to identify the pressures on the Toon River upstream of the apparent erosion location and to define the extent of morphology, hydrology and ecology surveys which may subsequently be required along the Toon River and within the alluvial woodland of The Gearagh. It was agreed that ESB International would be responsible for carrying out this scoping exercise on behalf of ESB, which would be presented to the working group following the publication of the Conservation Objectives of The Gearagh SAC.

The scoping exercise included:

- A literature review of all relevant published and accessible un-published material relating to The Gearagh woodland and Toon River catchment.
- The collation of datasets containing relevant environmental, hydrological, geological, morphological and land use/management data, and their incorporation into a Geographic Information System (GIS) geodatabase.
- Consultation with key stakeholders as well as individuals with a particular interest in the site, including the original complainant and local landowners.
- Preliminary hydrology, morphology and ecology walkover surveys to facilitate geographical targeting of surveys subsequent to the scoping stage.
- Recommendations for further surveying and next steps in relation to site monitoring and possible restoration.

This report presents the results of the scoping exercise.

1.2 Acknowledgements

The authors of this report wish to acknowledge the assistance of the members of the Project Steering Group, comprising representatives of:

- Department of Housing, Planning, Community and Local Government
- National Parks and Wildlife Service
- Cork County Council
- Electricity Supply Board

The following parties were also engaged with as part of informal consultation, during site visits or as a result of the data gathering exercise. The authors wish to thank them all for their time and valuable input.

- Kevin Corcoran, West Cork Ecology Centre
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- Jervis Good, National Parks and Wildlife Service
- Simon Harrison, University College Cork
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- John Martin, Office of Public Works
- Michael Ward, Ordnance Survey Ireland
- Tony Brown, University of Southampton
- Dermot Horgan, Local Landowner
- Sean Ó Lionard, Local Landowner
- Declan O'Mahony, Independent Film Director

2 Literature Review

2.1 Scope of literature review

This literature review is divided into a number of sections, the first two of which aim to summarise the key aspects of the ecological and hydrological functioning of a wooded anastomosing river system as present at The Gearagh. The remaining sections present a summary of land use (and land use change) within the site and in its general locality.

The review therefore facilitated the rest of the scoping exercise by placing the available empirical data, consultation feedback and site survey findings in the context of the best available background information relating to The Gearagh and its constituent habitats.

2.2 Anastomosing river systems

Makaske (2001) presents an overview of anastomosing river systems in the paper "*Anastomosing rivers: a review of their classification, origin and sedimentary products".* The main aspects of this publication are summarised below:

Anastomosing rivers are an important category of multi-channel rivers occurring on alluvial plains. They predominantly form under comparatively low-energy river flow conditions. Makaske (2001) proposes a definition of an anastomosing river as being "*composed of two or more interconnected channels that enclose flood-basins".* Such rivers are generally formed by 'avulsions', i.e., the formation of new channels on the floodplain caused by flow diversions.

Avulsion leads to the development of anastomosing rivers in two ways: (1) by formation of bypasses, whereby older segments (comprising channel belts) that become bypassed remain active for a protracted period; and, (2) by subsequent splitting of avulsive flows, leading to concurrent scour of multiple channels across the floodplain. Both types may coexist in a single river system. However, the first may be a long-lived floodplain-wide phenomenon, while the latter may only represent a developmental stage in the avulsion process on a limited part of a floodplain.

O'Connor (2015), notes that anastomosing rivers:

- Often have saucer shaped islands;
- Often have channels with high sinuosity;
- Comprise channels which are often much narrower than intervening islands formed;
- Have angles of bifurcation of channels wider (often at obtuse and right angles) than in braided rivers (usually at acute angles);
- Occupy 'floodbasins' which are flat, shallow, poorly drained floodplain depressions bounded by natural levees of active or abandoned channels or other uplands;

- Are classified as a composite form of a river system which may be comprised of multiple channel belts. The individual channel belts may have braided, meandering or straight channel areas.

The geomorphological processes in anastomosing river systems are of two kinds. Firstly, the processes associated with avulsion which lead to the creation of multiple channel belts. Secondly, the processes which determine the localised morphology of individual channel belts within the system. Climate and local geology are extremely important external controls of these processes.

Frequent avulsion events occurring in combination with slow abandonment of old channels can lead to the continuing coexistence of younger deepening channels and old vertically infilling channels, composing an anastomosing system at any given moment in time.

Long-lived anastomosis, as is the case with The Gearagh, is dependent on a suite of specific environmental conditions which prevent a river from achieving a single dominant channel.

Avulsion frequency in anastomosing river systems range from highly dynamic to semi-static. In the former, anastomosis results from the frequent formation of new channels. By contrast, in the latter, anastomosis appears to predominantly arise as a result of particularly slow infilling of old channels after infrequent formation of new channels.

Makaske (2001) concludes that it is apparent that some extensive anastomosing river systems exist in equilibrium with stable external conditions. The high lateral stability of individual channels in anastomosing rivers is envisaged to be a product of low stream power in combination with erosion-resistant riverbanks. Both of these environmental conditions are strongly correlated with minimal gradient along a floodplain.

However, while the physical morphology of anastomosing river systems can be quite similar, it must be appreciated that the processes driving catchment-specific anastomosis can vary significantly between sites. Anastomosing rivers can therefore be considered an example of ‘equifinality’, i.e. different combinations of processes or causes producing a similar final form.

2.3 Classification of woodland types

2.3.1 Ancient and secondary woodland

Perrin et al. (2008) defines ‘ancient woodland’ as areas of the countryside that have had continuous woodland cover *since before planting and afforestation became common practices*. These sites are thus more likely to have natural origins and may form a link with the prehistoric wildwood that once covered much of Europe (Rackham, 1980), although all are likely to have been managed at some time, and may bear little resemblance to the original forest cover.

Cudmore (2012) follows a somewhat alternative approach, wherein 'ancient woodlands' are generally defined as those *that have been continuously wooded since at least the oldest available historical data*. By contrast, 'secondary woodlands' are those woodlands that have established since that date on sites that had previously been used for agriculture. For this purpose, Cudmore's use of the term 'ancient woodland' refers to sites that have not been used for agriculture since the threshold date of 1650, which is when the first comprehensive survey (the 'Civil' survey) of Irish land took place. Secondary woodlands are defined by Cudmore as those *established naturally within the past 200 years*. As The Gearagh formed the primary component of Cudmore's 2012 thesis, her definition of ancient and secondary woodland will be utilised as part of this scoping exercise for consistency.

Ancient woodlands also often contain communities of plants and animals that are rarely found in more disturbed, secondary woodland or plantations (Hermy *et al.*, 1999). Extant areas of ancient woodland are therefore important sites for the conservation of these species both as refugia and as a source of colonists for new habitats (Goldberg *et al.*, 2007). Although ancient woodlands have a history of continuous tree cover, many have been subject to a range of management practices in the past. Indeed, exploitation is an integral part of the history of most woodlands, and so present-day ancient woods are often highly varied in structure and composition (Rackham, 1980).

Only 123 stands of ancient woodland still remain in the Republic of Ireland (Perrin and Daly, 2010), and 1,033 hectares in Northern Ireland (Anon., 2007); this corresponds to approximately 10% of all native woodland sites across the whole island or just 0.1% of the total land cover.

2.3.2 Alluvial woodland

The term 'alluvial woodland' covers a suite of habitat types. A relatively generic definition of alluvial woodland from the European Commission (2007) states that all types of alluvial woodland occur on heavy soils that are periodically inundated by the annual rise of river levels, but that are otherwise well drained and aerated during low water. Such woodland is a priority Annex I habitat (Code 91E0). A number of variants of this habitat exist, of which *riparian forests of Fraxinus excelsior and Alnus glutinosa (Alno-Padion) of temperate and Boreal Europe lowland and hill watercourses* are the most common type to be found in Ireland. These occur on heavy soils which are periodically inundated by the annual rise of river levels, but which are otherwise well drained and aerated during low water. The herbaceous layer includes many large species such as *Filipendula ulmaria, Angelica sylvestris* and *Carex acutiformis*, vernal species such as *Ranunculus ficaria* and *Anemone nemorosa*, and other indicative species such as *Carex remota, Lycopus europaeus, Urtica dioica* and *Geum rivale* are also listed. Woodland in The Gearagh falls into this classification.

In addition there are gallery forests of tall willows (*Salicion albae*) alongside river channels and occasionally on river islands, where the tree roots are almost continuously submerged. They are dominated by *Salix alba, S. viminalis* and *S. triandra*, sometimes with *S. cinerea* but alder is relatively rare. There is usually a luxuriant herb layer comprising, amongst others, *Phalaris arundinacea, Urtica dioica and Filipendula ulmaria*.

A functioning alluvial forest with a good structure is a multi-layered system, although the individual layers may be less distinct than in oak woods. Non-native species should be no more than occasional, with a cover not exceeding 10%, and preferably absent, although an exception is made for gallery woodlands in which non-native species of willow may be frequent. Alluvial woodlands should have a good complement of dead wood, including coarse and fine, standing and fallen dead wood, to accommodate the greatest possible range of invertebrates and other saproxylic organisms.

2.4 History of The Gearagh

The present-day ecology of The Gearagh site is strongly influenced by its historic land use. While portions of the central parts of the site are likely to have remained relatively un-impinged by human activities, other peripheral areas have been subject to different management regimes. Cudmore's (2012) thesis outlines in great detail the changes which are likely to have occurred in and around the woodland, a tabular summary of which is presented here.

Table 2.1 – Timeline of woodland development and change at The Gearagh

Early post-glacial period (11,000 – 7,000 BC)	*(Based on general successional habitat change in Ireland)* Some open grassland, tundra and low alpine scrub. *Juniper* scrub progressively replaces meadows. Arrival of *willows* and *birch*, replacing Juniper and leading to open woodland. Hazel replace birch, with arrival of pine leading to reduction in hazel. Oak and elm arrive, out-competing pine on lower more fertile soils. Successive diversification of forests, to include other plant species.
Mesolithic period (7,000 - 4,200 BC)	*(Based on general successional habitat change in Ireland)* Alder arrived late to the south-west of Ireland, approximately 5,000 BC (Mighall et al., 2008). This tree is tolerant of moist soils and so was able to out-compete pine on poorly-drained sites. However, pine would have still been found on the more acidic soils, amidst a canopy of elm, oak and hazel. No agriculture in Ireland – Forest cover reaches maximum.
Neolithic period (4,200 - 2,000 BC)	Elm declines (most likely due to pandemic disease possibly initiated or exacerbated by humans) Neolithic farmers clear woodland on a limited scale, extending in from coasts. Secondary woodlands with more ash.

	Minimal Neolithic archaeological evidence from Gearagh indicates that such clearance unlikely here.
Bronze Age (2,000 - 500 BC)	Expansion of grassland and arable land, loss of pine from country, replaced by oak, alder and hazel. Blanket and raised bogs expand. Archaeological evidence (including stone circles) highlights human presence around Gearagh; likely that some woodland clearance takes place with secondary woodland establishing.
Iron Age (500 BC - 500 AD)	Decline in agriculture possibly due to deteriorating climate; woodland re-establishes in abandoned areas (hazel, birch and ash). Late Iron Age expansion in agricultural clearance again probably limited close to The Gearagh, and in south-west Ireland as a whole (minimal archaeological evidence of Iron Age settlements etc.)
Early Medieval period (500 - 1000)	Woodland resources for settled populations (in ringforts etc.) are limited (tracts of land under Brehon law); coppicing of understories becomes commonplace, with large trees allowed to reach maturity for structural timber. Inaccessibility of The Gearagh would have limited its value as a wood/timber resource.
Late Medieval period (1000 - 1650)	Deteriorating climate, invasions, famine, and the Black Death resulted in economic decline and an overall decrease in the population of the country; lack of exploitation leads to increased density of existing woodlands. The Gearagh lies within lands of MacCarthy and therefore escapes exploitation by English settlers.
Stuart and Cromwellian plantations (1650 – 1842)	National woodland cover likely to be less than 3%, though Cork likely to have reached almost 6%. The majority of woodlands were dominated by a mixture of Betula, Corylus, Alnus, and Quercus. Areas without significant ironworks, such as the upper Lee Valley, received little investment in infrastructure. The only significant threat to The Gearagh is therefore likely to have come from agriculture. In 1694, however, the fourth Earl of Clancarty forfeited his lands (Ó Murchadha, 1993), and the new owners immediately felled any standing timber for additional funds (Dickson, 2005). Cleared areas used for cattle and sheep grazing. It is likely that The Gearagh survived as a scrub woodland, although the margins were undoubtedly altered by exploitation and agricultural encroachment. Drainage of the land surrounding the River Lee was attempted in the late 1700s. However, these efforts proved difficult to maintain and were subsequently abandoned. This

	unsuccessful attempt to drain and channelise the River Lee meant that The Gearagh remained relatively unaltered during this period of increased exploitation and land improvement. Post-famine, it is likely that cleared parts of The Gearagh used for marginal grazing were abandoned.
1842 – 1904	The Ordnance Survey (OS) map of 1842 delineates key morphological features of The Gearagh for the first time. It shows that the southern part of The Gearagh, which was still mostly wooded, was divided into the townlands of Gearagh West and Gearagh East. Much of the land around The Gearagh was still liable to flooding; many abandoned channels can be seen to the south of The Gearagh in the area of Annahala East and Annahala West, denoting the former extent of the anastomosing woodland system. These areas were marked 'Liable to Floods'. Dairying one of the most important agricultural activities at this time and a new creamery had been established in Teergay just south of Toon Bridge. During this period, abandoned areas of along the north of The Gearagh revert to scrub and young woodland (e.g. Ilaunmore islands), as seen in the 1904 second edition OS map.
1904 – 1955	Areas of The Gearagh which had been grassland in 1842 and scrub in 1904, are now shown on Ordnance Survey maps as mature woodland. Indeed, most islands had reverted to woodland or at least to scrub by the time of the 1938 map revision (see Appendix 4). Botanical interest in site increases with a number of flora surveys taking place.

Prior to the development of the Lee hydro-electric scheme (see Section 2.5), The Gearagh woodland in the early 1950's, covered an area of about 180 hectares and extended from the townland of Teergay to Lee Bridge (see Figure 2.1 and Appendix 4).

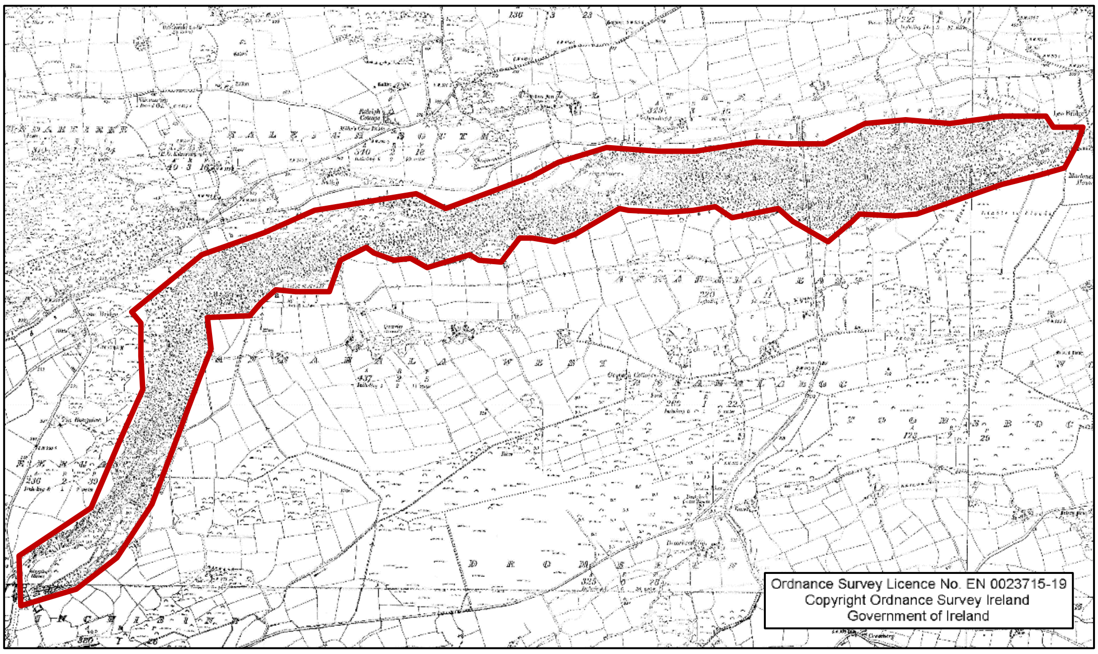

Figure 2.1: Extent of The Gearagh woodland in 1938, approximately 180 hectares (Ordnance Survey 1:10,560 mapping background)

Based on an analysis of the above, and a review of the Ordnance Survey map revisions between 1842 and 1938, Cudmore (2012) presents a map outlining the origins of the extant woodland in The Gearagh. A composite drawing based on Cudmore's map overlaying recent aerial imagery is presented below in Figure 2.2.

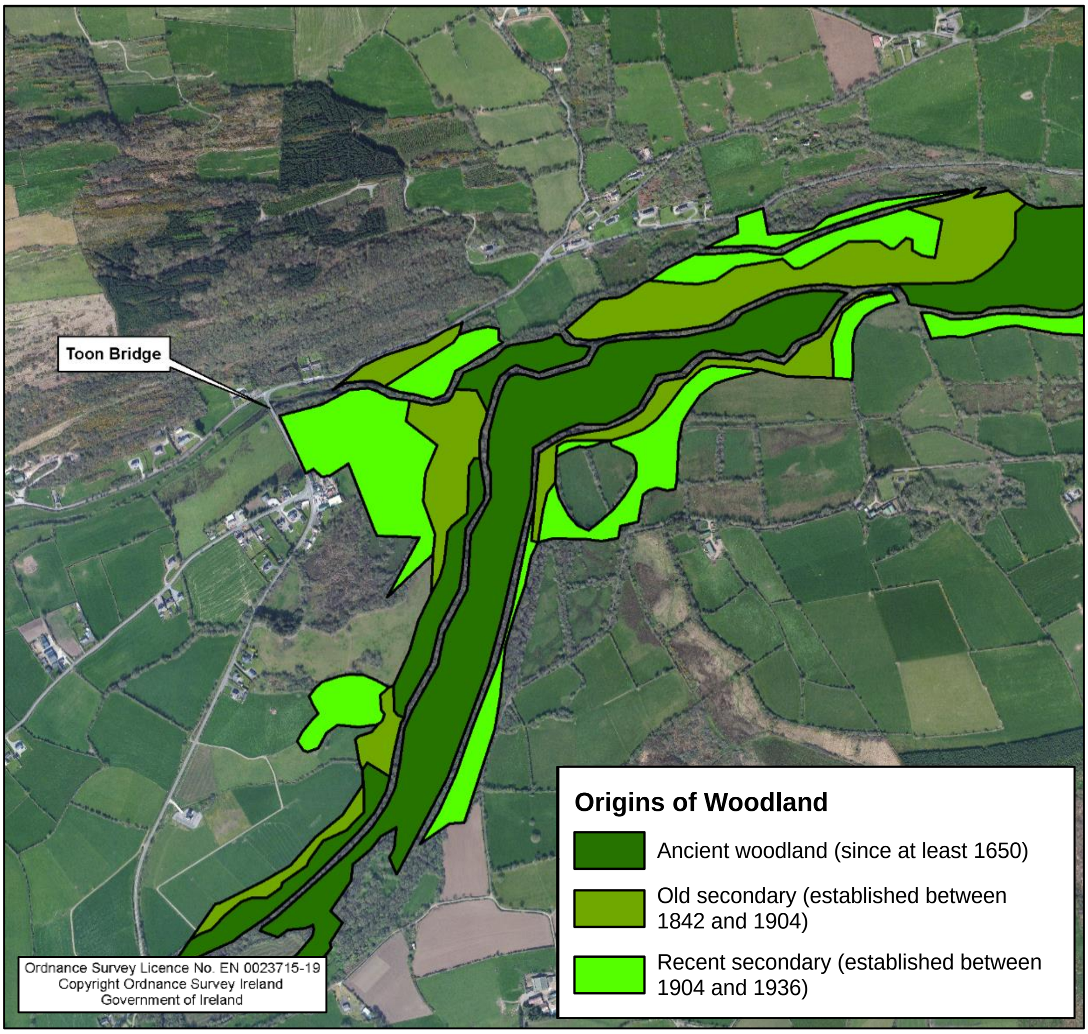

Figure 2.2: Origins of extant alluvial woodland at The Gearagh (based on Cudmore, 2012)

2.5 Development of the Carrigadrohid Reservoir

Subject to the River Lee Hydro-Electric Scheme Approval Order, 1949 (S.I. No. 321/1949) the ESB constructed two hydro-electric dams on the River Lee, downstream of The Gearagh. The Carrigadrohid dam would flood a significant area of the land upstream, including a large area of The Gearagh woodland. ESB purchased the lands along the proposed Carrigadrohid reservoir, as well as the complete extent of The Gearagh woodland at that time. All scrub and trees in the woodland growing below the projected high water level in the Carrigadrohid reservoir were felled (O'Donoghue, 1996), an exercise which began in 1953, in parallel with the construction of the dam. This clearance took over three years, with the flooding of the reservoir beginning in October 1956 (O'Connell, 2008). It is estimated that approximately 60% of the former woodland was lost (NPWS, 2016). The resultant reservoir covers the area from Lee Bridge to Annahala Bridge, and westwards of Illaunmore Island.

At low water, the reservoir exhibits a braided delta-like formation, outlining the former anastomosing channels of this part of the woodland; west of the causeway, these are colonised to varying degrees by reedbeds and willow scrub, but are almost exclusively devoid of complex vegetation east of the causeway. The cut stumps of the cleared area of woodland are easily viewed from the Lee Bridge and from the Port Road causeway which transects the reservoir from north to south.

The Regulations and Guidelines for the Control of the River Lee define minimum and maximum guideline level regimes for Carrigadrohid and Inniscarra reservoirs and discharges from the stations. During flood periods, more formal Regulation levels are defined. These level and discharge regimes were devised to cater for dam safety. The operational regime of the reservoir defined in the aforementioned Regulations covers a level range of 61 m OD and 64.5 m OD. The reservoir (Carrigadrohid) was created for the purpose of electricity generation. With the development of the Lower Lee Flood Relief Scheme, under the aegis of the OPW, this may in the future be expanded to include flood alleviation.

The operation of the generating stations at Carrigadrohid and Inniscarra influence water levels in their associated reservoirs. These reservoirs extend to almost half of the natural river length. The levels and flow regimes in tributaries such as the Toon, Dripsey, Sullane and Laney are also affected near their confluences with the Lee. Flows from the Carrigadrohid and Inniscarra reservoirs are controlled by the station. However, two major tributaries, the Bride and Shournagh, join the Lee downstream of Inniscarra and significantly influence flows in the Lee.

Adherence to the level bands outlined in the Regulations provides a relatively stable environment for water dependent habitats and species. In the case of the Lee, acknowledgement of the requirements for The Gearagh are critical in this regard. It is notable that the fluctuating nature of the reservoir facilitates a diverse ephemeral flora, which develops on the exposed mud during low water periods, corresponding to the E.U. Habitats Directive Annex I category 'rivers with muddy banks with Chenopodion rubri p.p. and Bidention p.p. vegetation'.

Cudmore (2012) notes that "*the least disturbed part of the woodland occurs in the upper reaches of The Gearagh between Teergay and Toon Bridge…[t]his area forms the central part of the ancient woodland section in The Gearagh. It lies well above the extent of the reservoir and is rarely affected by fluctuations in water level caused by the dam",* however, this appears to be anecdotal, and no evidence was presented to support this statement. Conversely, information provided by local landowners during the site visit indicated that during severe flood conditions when the reservoir is close to capacity, flow velocities through the woodland slow down, and subsequently water levels can be seen to back up in the southwestern extent of The Gearagh, leading to potential localised flooding of land and properties. Again, this is anecdotal and therefore data collection relating water levels in the woodland to the operational regime of the reservoir would be required to identify the measureable range of effect.

2.6 Ecological value of Carrigadrohid reservoir

While nominally a heavily modified waterbody under the Water Framework Directive, the Carrigadrohid reservoir is of notable ecological value. It is of significance to breeding and wintering waterfowl, resulting in the designation of the site west of the causeway as a Nature Reserve in 1987 and subsequently as a Special Protection Area (SPA).

The site is also designated as a Special Area of Conservation (SAC), the boundary of which overlaps to a large degree with the SPA, though also includes the large expanse of water between the causeway and Lee Bridge which is most influenced by the operational level changes in the reservoir.

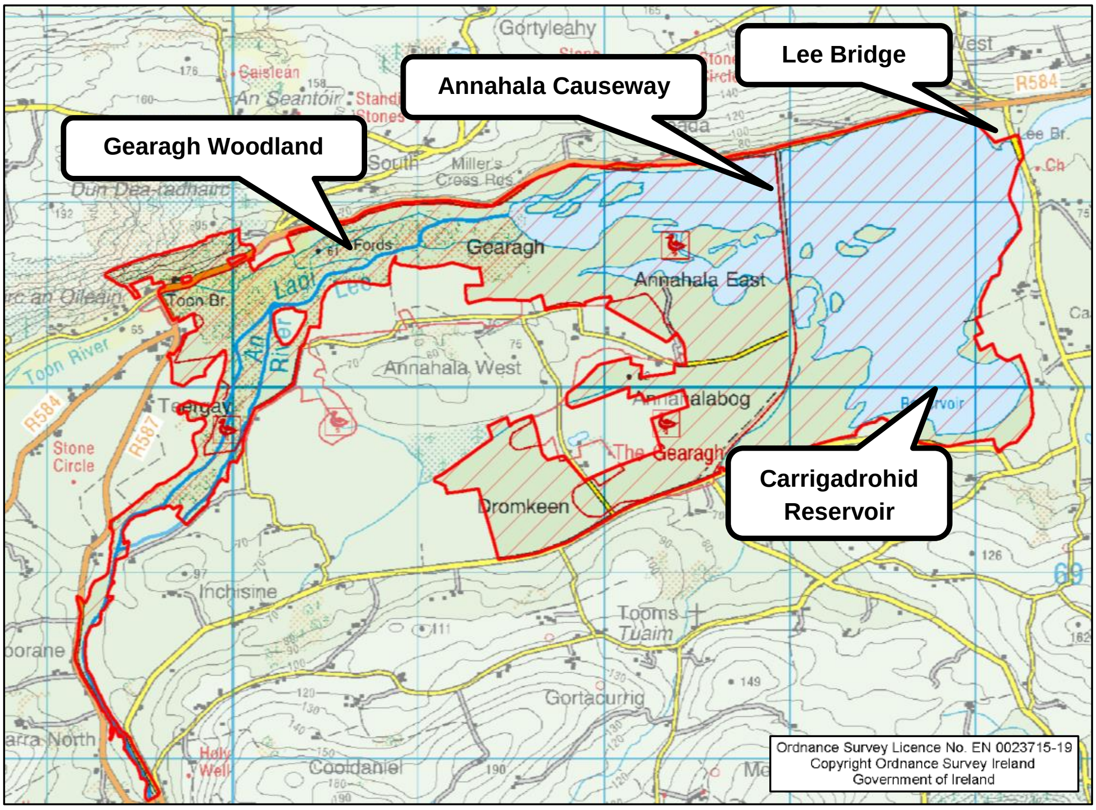

Figure 2.3: The Gearagh SAC

At least five species of pondweed occur in the reservoir, while at low water levels, a diverse ephemeral flora develops on the exposed mud, corresponding to the E.U. Habitats Directive Annex I category ‘rivers with muddy banks with *Chenopodion rubri* p.p. and *Bidention* p.p. vegetation’ (NPWS 2015); this is a qualifying interest habitat for the SAC. Otter also occurs widely throughout the entire SAC, and is another qualifying interest. An oakwood corresponding with the E.U. Habitats Directive Annex I category ‘Old Oak Woodlands’ occurs just north of Toon Bridge, though this qualifying interest is entirely a terrestrial habitat and thus not influenced by the operational regime of the reservoir or the hydrology of the rivers entering the main Gearagh woodland.

The majority of the extant wooded area of The Gearagh comprises alluvial woodland which qualifies as a priority habitat under Annex I of the E.U. Habitats Directive. River channels are an inherent key ecological aspect of the woodland. Within the heavily forested channels there is little or no aquatic vegetation, but where the canopy is more open, diverse instream vegetation occurs. These areas correspond with the E.U. Habitat type 'floating river vegetation'. The anastomosing feature of the alluvial woodland is particularly pronounced along the course of the Lee, with the river breaking up into up 15 channels along some cross sections. The islets which form the channels are notably well-drained. The NPWS SAC site synopsis notes that "*The Gearagh still represents the only extensive alluvial woodland in Ireland or Britain, or indeed west of the Rhine in Europe. For this reason it is a unique site…[t]he international importance of the site is recognised by its designation both as a Ramsar site and as a Biogenetic Reserve*." Freshwater pearl mussel (an E.U. Habitats Directive Annex II species, though not a qualifying interest for the site at present) and several species of freshwater sponge are also known to occur in the anastomosing channels of the woodland.

The attributes and targets for the Alluvial Woodland component of The Gearagh are detailed in the Site Specific Conservation Objectives[1] for the SAC. These are reproduced in Appendix 2.

2.7 Ecology of The Gearagh woodland

With respect to the remaining extant area of The Gearagh woodland, as described by Brown (1997), the ecosystem consists of a myriad of small islands and islets dissected by hundreds of channels. Mean island length is only 40 m. The majority of the islands are wooded with typical floodplain trees such as *Alnus glutinosa, Salix caprea, Quercus* spp. and *Corylus avellana*, but also dry-land trees and shrubs such as *Betula pubescens, Fraxinus excelsior, Crataegus monogyna, Ulex europaeus* and three species of *Prunus* (*avium, spinosa* and *padus*); before 1954 *Taxus baccata* was also present.

As noted by Perrin et al. (2008), the current woodland flora is fairly consistent throughout, with sessile oak (*Quercus petraea*), *Q. robur*, ash (*Fraxinus excelsior*), hazel (*Corylus avellana*) and Hawthorn (*Crataegus monogyna*) the main tree species. *Viburnum opulus* is also frequent as seedlings and saplings. Ground flora species include *Hedera helix, Athyrium filix-femina, Euphorbia hyberna, Sanicula europaea, Primula vulgaris, Filipendula ulmaria, Caltha palustris, Veronica montana* and many bulbs of *Allium ursinum* visible. Bryophytes are abundant, with *Fissidens* spp., *Thamnobryum alopecurum, Chiloscyphus pallescens* and *Conocephalum conicum* the species seen most frequently.

This relatively even mix of species (comprising six to eight tree species) exists even in islands as small as 2 x 10 m (Brown et al., 1995). The reason for this is the uneven topography of the islands caused by mounds, pits and flood-channels. The mounds are mainly the result of windthrow of trees. As the tree leans or falls a mound of soil is moved as the root mass is lifted. Also, when a tree falls, pits are created. Another

[1] https://www.npws.ie/sites/default/files/protected-sites/conservation_objectives/CO000108.pdf

process that creates pits is overbank (flood) flow scouring around coppice tree bases and standard trees; this process also enlarges tree-throw pits and creates saucer-shaped depressions which have been shown to favour the regeneration of willow (Brown et al., 1995). The result of these processes is that there is over 1 m relief above bank height and a variation in soil from gleyed to free- draining.

Windthrow also increases channel-edge length because when trees fall they create bank embayments which are horseshoe-shaped cuts in the bank. These can also be formed both by root dislocation (Davis & Gregory, 1994) and by flow-deflection (Keller & Tally, 1979). The embayments are important dead-water zones where organic matter and silt accumulate.

The channels also promote biodiversity through the co-existence of dead(still)-water and live(moving)-water channels. The channels can be divided into three types:

1. Relatively straight, trapezoidal, gravel-bedded, fast flowing, glide-run type channels;
2. Sinuous, irregular, v-shaped, silty-mixed bed, slower-flowing channels; and
3. Channels on the islands only occupied by water during and after overband floods (flood-channels).

A significant area of The Gearagh is taken up by junctions between these channel types with the additional complexity produced by tributary junction bars and scour-holes. In the trapezoidal channels the gravels are iron and manganese cemented and up to 20% of area can be covered by freshwater sponges, particularly *Ephydatia fluviatilis*, which require high levels of suspended organic matter for feeding and a stable bed for attachment. The more irregular muddy channels contain more fine and coarse organic matter and the banks tend to be stepped, promoting a rich riparian vegetation of herbs, grasses and rushes.

From a review of recent aerial photography, the River Lee is relatively difficult to discern in the southern portion of the site, as it divides into up to fifteen channels. The Toon River, by contrast appears to be dominated by a single main channel which becomes more anastomosed once the influence of the Lee asserts itself.

Debris dams (arising variously from fallen trees, sediment deposition in smaller channels, or low-hanging vegetation trapping debris) are a common feature of The Gearagh woodland. A small area in the Lee section of the woodland (with four channels and one debris dam) was monitored through two floods in 1991 and 1992 (Harwood & Brown, 1993). This study found that during floods, river energy is effectively dissipated by the shedding of flow out from trapezoidal, gravel-bedded channels to channels of lower hydraulic efficiency, and by overbank resistance. It is believed that this is responsible for the persistence of debris dams and the co-existence of different channel types within the woodland. Many of the dams in the site were found to be living and growth suggested that some were in excess of 10 years old.

It is worth noting that the wooded part of The Gearagh is predominantly inaccessible to humans due to the character of the anastomosing channels. Access and site navigation both by foot and boat is extremely problematic and is likely to be classed as dangerous during periods of elevated water levels, when the river channels become non-wadeable.

2.8 Influences on The Gearagh woodland post-reservoir development

During the period following construction of the Carrigadrohid dam, there have some been small-scale landscape changes around the periphery of the reservoir, as well as other apparent changes along the Toon River and within The Gearagh woodland. These are outlined in the subsections below.

2.8.1 Woodland re-establishment

Since the establishment of the reservoir, agricultural activity on marginal land within and immediately adjacent to The Gearagh appears to have declined. Some summer cattle grazing still occurs in some parts of the woodland, though any impacts of this are localised (Cudmore, 2012).

A direct comparison of aerial imagery from 1974 and 2012 (see Figures Figure 2.6 and Figure 2.10: 2012 Aerial Imagery) reflects how a significant area of enclosed fields and islands along the northern edge of The Gearagh woodland (below Raleigh South) which had historically been kept clear for grazing have become progressively abandoned and colonised by scrub and early secondary woodland. Similar large areas of re-establishment can be seen north of Annahala West, as well as south and west of Toon Bridge. Based on a rough comparison of these aerial images, it is conceivable that the wooded area of The Gearagh has filled in and expanded by 10-20% during this 40-year period. Without specific surveys to confirm the species composition of these expanded areas, it is difficult to conclude what type of secondary woodland has arisen, but it is expected that it will predominantly comprise areas of willow, birch and alder.

2.8.2 Hydrological changes upstream

The key aspects of the complaint made to the European Commission in 2013 concern perceived changes to the hydrology of the Toon River upstream of The Gearagh. In this communication, the complainant (Mr Kevin Corcoran, West Cork Ecology Centre) states that:

> *"…the Toon, has of late undergone serious changes to its hydrology to facilitate afforestation of its uplands and now it is to face further drainage to accommodate wind farms. This drastic change to the Toon river hydrology is being ignored by the planners and as a result The Gearagh alluvial forest is being affected by it due to an increase in flash floods, which are causing island and channel destabilisation. It is scientifically clear that when one cuts into the bogs of the uplands they begin to bleed to death and as they dry out and disintegrate, the rainwater that falls*

rapidly drains away, to seriously impact on the lowlands below through increased flash flooding.”.

Mr Corcoran expands upon the above comment in his submission (January 28th 2016) with reference to the Cleanrath Wind Farm planning application [Planning Reference: 15/6966] as follows:

> “*Beginning in the late 1980's many of the natural ecological features that influence the hydrology of the Toon River have been systematically removed from the Toon Valley catchment. This has resulted in a progressive and abnormal increase in flash flooding that is effecting enormous erosive damage to the anastomosing structure of The Gearagh. The following outlines the cause of these destructive floods -*
>
> > *• The reclamation of farms in the upper and lower floodplain plateaus has resulted in the removal of most all hedgerows and the drainage of the floodplains wet-meadows.*
> >
> > *• The dredging of the Toon river channel and its embankment to contain the flood waters from spreading over the natural flood plain.*
> >
> > *• The continued expansion of coniferous forestry plantations in the upland heaths about the upper flood plain has also resulted in extensive drainage of these areas.*
>
> *Up to 1985 very little physical change had been effected on the natural features of the three floodplains, whereby their ecological, flood mitigating features insured destructive floods associated with high precipitation were much less of an occurrence. This is because the various features insured that the release of the rain water was spatially spread out over a longer run-off period. Consequently a more moderate flood occurred that lasted longer and rarely reached extreme peak flows. This insured the floods had less destructive erosive power.*
>
> *By 2015, as the flood attenuating features of the river's natural ecology were removed, the heavy precipitation that normally took several days to exit from the land now exits in a matter of hours. Following a severe storm event the increasing level of drainage works have caused a corresponding increase in rain-water run-off from the land, so-much-so that the erosive effect of flash flooding has increased both in frequency and intensity. Those results closer to 2015 indicate that severe flood events now occur more often, they arrive earlier and have shorter flows but with exceedingly higher peak volumes. This has magnified the erosive power of the floods three fold. In effect they arrive as destructive flash floods.*
>
> *The final destination of this abnormal flooding is The Gearagh alluvial forest. The immediate effects of this scenario, has been a progressive erosion of The Gearagh's multi-stream complex into a single channel. Numerous alluvial islands are being washed away while several of the*

> *branching channels are either silting up or blocked by debris. This condition is very visible through Google earth maps as a distinct blue line, whereby the Toon River increasingly forms a single channel eating into The Gearagh forest at Toon Bridge*."

Mr Corcoran supplements this argument with an Opinion Statement from Professor David Harper of the University of Leicester, who conducted research and wrote on The Gearagh approximately 12-15 years ago. In this communication, Professor Harper asserts that:

> *"The past 30 years have seen more insidious, slow changes to the outer parts of The Gearagh that put at risk its whole structure and unique value. The greatest is the drainage of the Toon catchment, which results in greater and more powerful flood events sweeping down the channel, eroding the formerly-stable islands in the northern part of The Gearagh.*
>
> *This process must have started with the straightening of the Toon river to make its floodplain amenable to intensive agriculture (hence unavailable for temporary flood storage) some decades ago, accentuated by clearance of rough land for intensive agriculture (speeding rainfall runoff into drainage channels and the river) and by floodbanks along the river and tributary channels. The consequence of these actions together must have removed almost all the natural 'sponge effect' temporary flood storage from the middle and lower catchment, so that flood peaks are shorter and stronger. This has visibly eroded away islands that slowed the flood down as waters entered The Gearagh, preventing it from being diverted into many channels.*
>
> *The high risk now is that the Toon river, with too much power, slicing into The Gearagh - clearly visible on Google Earth as a broad straight blue line breaking the green canopy - will continue to push in, causing tree fall and island erosion from the ancient woodland parts. Comparison with the Lee entering The Gearagh from the south - a much larger river, but one with natural 'sponge effect' of temporary flood retention in lakes - illustrates the problem. The Lee immediately anastomoses north of the road bridge, as the Toon once did west of Toon Bridge."*

The above commentaries highlight the specific issues of downstream impacts of changes to the upstream hydrology of the Toon River. From a review of available aerial imagery (1974, 1995, 2000, 2005 and 2012), it is indeed apparent that in recent decades, some agricultural intensification has taken place along the Toon River upstream of The Gearagh, with field boundaries being successively denuded in some areas, particularly on the Coolcaum floodplain immediately upstream of Toon Bridge.

This lower stretch of river has a distinct canalised aspect and from information gleaned from local landowners during the site visit, is subject to occasional removal of instream vegetation to reduce flooding of the adjacent fields.

Other land use changes in the upper reaches of the Toon River can be discerned via the CORINE datasets (1990, 2000, 2006 and 2012). Between 1990 and 2012 (see composite map in Figure 2.4 and Appendix 4, Maps 13-16), the majority of land cover change in the headwaters of the catchment relate to forestry.

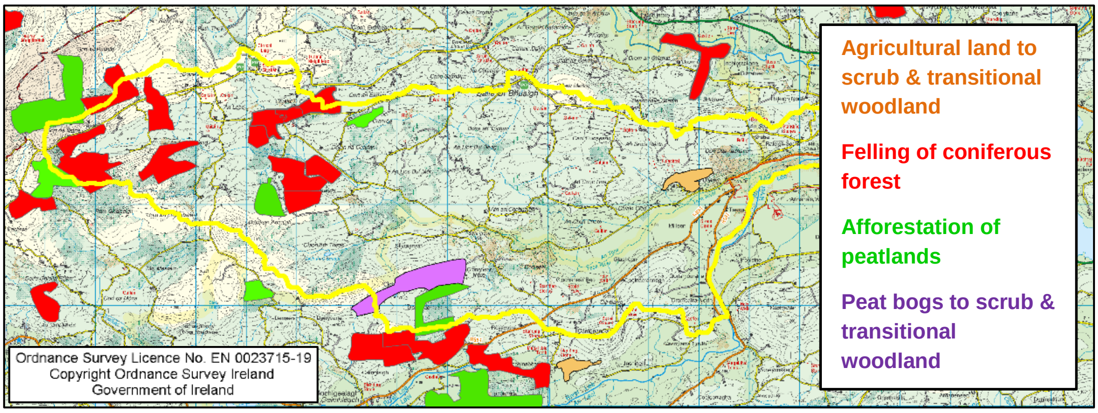

Figure 2.4: CORINE Land Use Change Composite 1990-2012

Taken in combination with available imagery for the area, this data reflects heterogeneous changes in land use patterns in the sub-catchment, with some areas subject to felling and other areas being used to establish new or second rotation forestry. Areas of clearfell and newly established forestry are likely to have less rainwater attenuation capacity, while areas of more complete canopy cover are likely to slow down the release of water to the sub-catchment.

2.8.3 Direct alteration of Toon River within The Gearagh

During the course of the literature review, correspondence was undertaken with Dr Daniel Kelly of the School of Botany, Trinity College Dublin. Dr Kelly specialises in woodland forest ecology and has a long-standing interest in The Gearagh. He is in possession of a number of relevant documents and academic papers on The Gearagh, including prints of aerial photos of the site taken before the woodland clearance in the 1950s.

Furthermore, Dr Kelly was able to furnish the authors of this report with a series of letters relating to significant events which occurred at The Gearagh in 1983 and again in 1984.

The first letter (from Dr Kelly to the then Ministers for Fisheries and Forestry), dated 19th October 1984, reads:

> *"I write to you concerning the conservation of the native woodland of The Gearagh, near Macroom. This is the only surviving fragment of a formerly extensive forested area that was destroyed in the 1950's to make way for the R. Lee hydroelectric scheme.*

> *The surviving woodland, in the vicinity of Toon Bridge, is of enormous scientific importance and educational value. It is unique in Ireland, and there is nothing like it in Britain either; its nearest parallel is in the forests of the Rhine, on the border of France and Germany. The Gearagh has attracted a lot of recent interest: the Young Scientist of the Year Award was given to Mr. T. Hickey, of Macroom, for his study of this area…It is therefore extremely dismaying to find that the surviving woodland has suffered severe damage in 1983 and again in 1984. A broad swathe has been bulldozed right through the wood below Toon Bridge, not only destroying the vegetation but threatening to affect the water-table, and hence threatening the very existence of this unique ecosystem. I ask you, Sir, to do all that is in your power to prevent further destruction, and to ensure that an effective conservation policy is instituted for the area."*

A second letter (from Dr Kelly to Mr J. M. McCarthy of Cork County Council Planning Department), dated 25th February 1985, presents a greater level of detail and includes a sketch map of the extent of the damage to the site. It reads:

> *"Thank you for your letter of 5th December 1984. I now enclose , as you requested, a map showing the location of recent damage to The Gearagh woodland. Within the zone marked 'Area of woodland destruction', a swathe has been cut through the woodland through felling of trees and destruction of islets, by bulldozer or similar machinery. The length of destruction is at least one mile, starting below the 300-yard mark downstream (east) from Toon Bridge. This was carried out during 1983-84. I enclose a photograph taken in 1984 to give some impression of the seriousness of the damage to this unique woodland.*
>
> *Besides the direct destruction and uglification, this damage affects a wider area; the artificial channels created have lowered the general water-table. I am informed that in mid-winter 1984-85 many of the natural stream channels in this area were still dry as a result of the interference described. Some of this damage to the wider ecosystem may be virtually irreversible. May I appeal to your Department to ensure that no further destruction of this kind is permitted."*

Scans of these letters are presented in Appendix 1; unfortunately the photo mentioned in the above letter could not be sourced before the publication of this report. The sketch map referenced above (hand-written notes on a six-inch map of the area, while very rough, and not to scale), shows the area of destruction to follow the course of the Toon River for at least a half of the distance between Toon Bridge and what was estimated to be the open water area of the reservoir downstream; see Figure 2.5.

This significant event has not been previously reported in any scientific literature or planning correspondence relating to The Gearagh. This is presumably because the majority of published scientific studies have focused on the anastomosing features of the more southern Lee component of the system, with the Toon component being relatively under-studied.

A subsequent letter (to Mr James White of the UCD Botany Department, from J.F. Williams, Secretary of the ESB), dated 18th April 1985, reads:

> *"Thank you for your letter of the 3rd April, addressed to Mr. O'Leary, together with a copy of your paper about The Gearagh Woodland, Co. Cork. Unfortunately, Mr. O' Leary died some months ago.*
>
> *The damage to the woodland below Toon Bridge in 1983 was caused by a man using a bulldozer in the mistaken assumption that he owned the land. The problem was brought up with him and he agreed not to cause further damage to the area. This man has also died. You may be assured that the E.S.B. are particularly sensitive about the preservation of The Gearagh."*

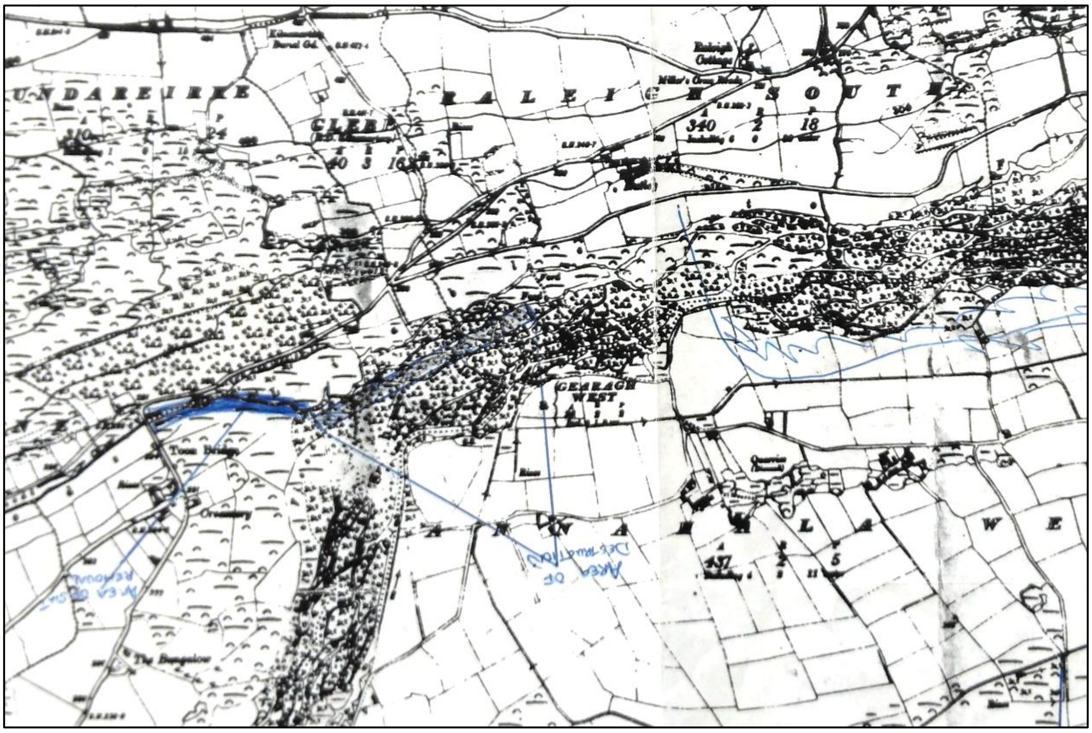

Figure 2.5: Scan of original sketch map of damage to Toon River in 1983/84: Sketch reflects 'Area of silt removal' immediately downstream of Toon Bridge, and 'Area of destruction' within woodland area. Presumed extent of reservoir is also shaded, providing possible scale for relative length of Toon channel alteration. Reproduced courtesy of Dr Daniel Kelly, Trinity College Dublin.

While the motivation of the aforementioned landowner remains relatively unclear, it is conceivable that the clearance of the Toon River channel was carried out in an attempt to reduce inundation of the land immediately upstream of Toon Bridge (and possibly in the northern stretch of the woodland), and thus reclaim some of this land for agriculture. A review of OPW and ESB flooding records from the early 1980s (via www.floodmaps.ie) does not indicate any significant flood events occurring in the Toonbridge area in the years immediately preceding these clearance works.

In light of the above information, comparing the aerial imagery of The Gearagh for 1974 and 1995 is significant (unfortunately OSI is not in possession of aerial imagery of the site for any year in the 1980s). The channel of the Toon River inside the woodland is relatively difficult to discern in the 1974 imagery, with the Lee actually being more distinct where it reveals a more open canopy along the southern boundary of the woodland. Furthermore, the width of the Toon channel where it can be clearly seen (i.e. just downstream of Toon Bridge) is considerably narrower than the contemporary channel and features a dense corridor of riparian vegetation and a large central island. In the 1995 image however, the channel of the Toon is extremely well defined and forms a clean break in the woodland canopy, extending from Toon Bridge to directly south of the houses on the Inchigeelagh Road in the townland of Raleigh South. This visible strip of open canopy is over 1 km in length, which relates to approximately half the distance between Toon Bridge and the open area of the reservoir, similar to the sketch map provided by Dr Kelly.

A review of the subsequent aerial images from 2000, 2005 and 2012 is suggestive of no further significant change in the appearance of the tree canopy along the visible Toon channel; see Figure 2.6 through Figure 2.10, all presented in black and white for direct comparison. Larger versions of these maps are presented in Appendix 4.

It is of note that the described damage along the Toon channel occurred prior to the designation of The Gearagh as a Statutory Nature Reserve (1987) and as a Site of Community Importance (1997).

Figure 2.6: 1974 Aerial Imagery

Figure 2.7: 1995 Aerial Imagery

Figure 2.8: 2000 Aerial Imagery

Figure 2.9: 2005 Aerial Imagery

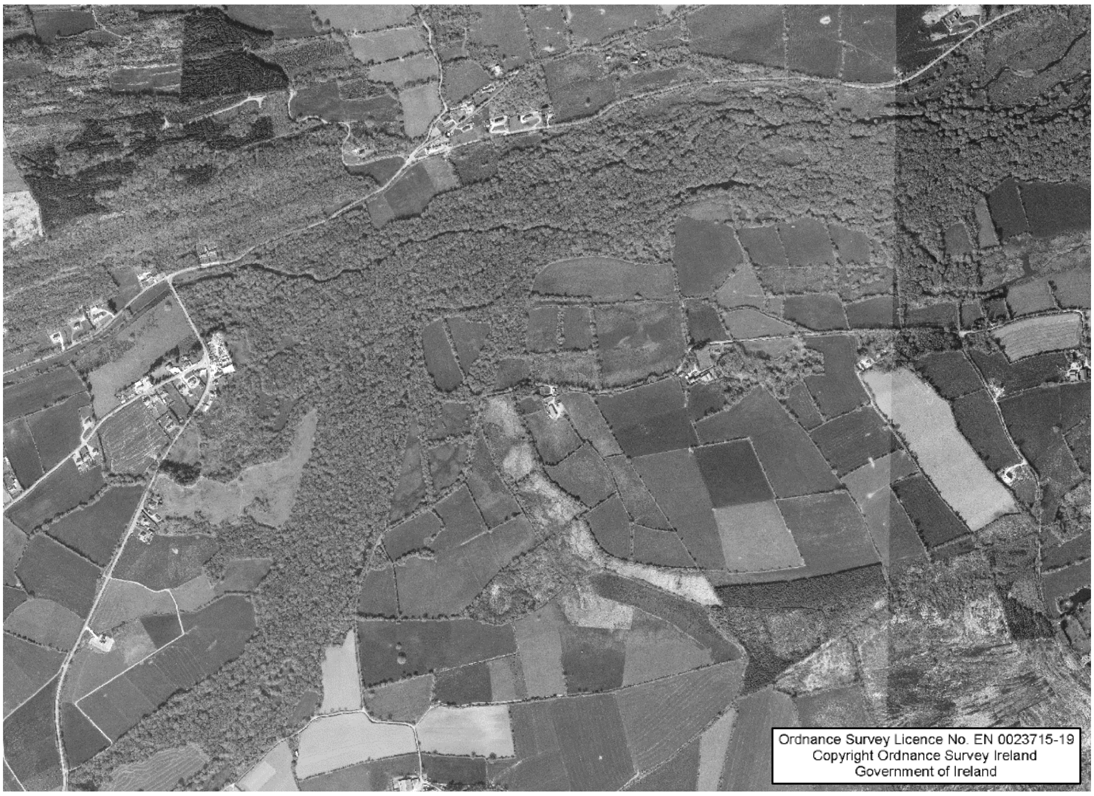

Figure 2.10: 2012 Aerial Imagery

In this context, it is arguable that the current functional hydrology of the Toon River within The Gearagh woodland has been significantly, if not permanently altered by a direct human intervention which occurred within the woodland over 30 years ago. While the route of the channel predominantly still corresponds to that seen in the six-inch maps, it is conceivable that numerous islets along this course were removed, the channel widened and the overall water table lowered to some degree. It is very likely that this has had the knock-on effect of the siltation or abandonment of some of the anastomosing channels to the north of the Toon channel. The anastomosing features are possibly less impacted to the south of the channel, as these areas are still strongly influenced by incoming flow from the Lee component of the system.

It is therefore reasonable to review the complainant's assertion that the contemporary dominant Toon channel has arisen as a result of increased erosion due to increased frequency and intensity of flash flooding within the Toon sub-catchment. While this may have been a rational assumption in the absence of any other evidence, the details of the alteration of the channel in 1983/84 provides a very strong alternative case for the current condition of the site. Indeed, the 'area of destruction' on the sketch map provided by Dr Kelly is quite similar to a sketch indicating 'Island loss and single channel formation' provided by Mr Corcoran in his submission regarding the Cleanrath Wind Farm Planning Application, as reproduced below in Figure 2.11.

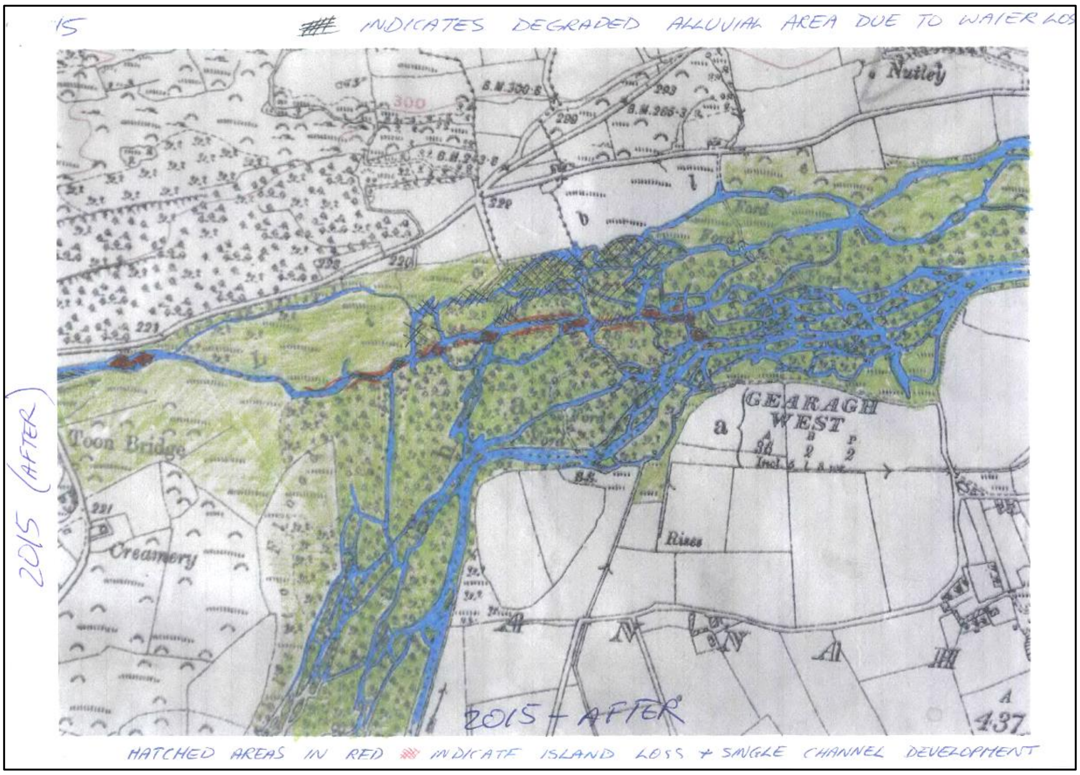

Figure 2.11: Sketch map by Mr Kevin Corcoran outlining areas of perceived erosive damage to Toon River channel and siltation of former anastomosing channels

Regardless of the origin of the existing dominant Toon River channel and its subsequent negative influence on the anastomosing channels to the north of the site, it can still be argued that there is ongoing potential for the artificially altered channel to be leading to systematic change in The Gearagh woodland. However, distinguishing new negative erosive features from remnant damage and expected background levels of channel change from natural tree fall is likely to be a difficult exercise without the existence of very specific topographic survey data.

3 Data Collation and Mapping

3.1 Data sourcing

3.1.1 Available data

The following datasets were collated as part of the scoping exercise:

- ESB Property Boundaries
- OSI Discovery Mapping
- OSI Six-Inch Mapping
- OSI Orthophotography 1995
- OSI Orthophotography 2000
- OSI Orthophotography 2005
- DigitalGlobe Aerial Imagery 2012
- OSI unrectified aerial imagery 1974
- NPWS Designations
- NPWS Conservation Objectives
- Water Framework Directive sub-catchment boundaries
- Corine land use data 1990
- Corine land use data 2000
- Corine land use data 2006
- Corine land use data 2012
- Coillte / Department of Agriculture private forestry property boundaries
- OSI Discovery river/stream courses
- EPA Soils & Subsoils
- GSI Geology
- OPW & Lee CFRAMS Flood Maps
- Lee CFRAMS LiDAR data
- Locations of Toon sub-catchment wind farm planning applications
- Locations and status of hydrometric gauges
- Local Met Éireann rainfall data (Ballyvourney & Macroom-Renaniree stations)

3.1.2 Poor quality or currently unavailable data

While a single EPA hydrometric gauge location exists on the Toon River (Ref:19023, Coolcaum, installed in 1979), the register of gauges on the EPA website notes that this location ceased recording in 2001. A request for access to the data for this gauge was submitted to the EPA as part of the data collection exercise.

EPA was able to supply the available collated flow and level data for this location. However, this station comprises a staff gauge only, so no continuous records are available. The data therefore only comprises 72 records over 22 years of discontinuous spot flow measurements noting river discharge and gauge depth (only 7 data points exist between 1996 and 2001). Due to the very discontinuous nature of the data (devoid of before-and-after river status etc.) it is of extremely limited value in relation to the historic hydrological behaviour of the Toon River.

Flood mapping related to the Lee CFRAMS project was collated for The Gearagh section of the Lee; a series of cross sections were surveyed on the Lee and a number of its tributaries during the compilation of the Lee CFRAMS. Unfortunately, these cross sections do not incorporate the main channel of the Toon River upstream of The Gearagh.

In relation to a currently inactive proposal to develop a pumped storage hydroelectric scheme connected to the Carrigadrohid reservoir, a limited hydrological survey of the Toon River was undertaken by Malachy Walsh and Partners in 2011 in relation to a possible bridge crossing of the river. Using the Mean Mid-Point Method for determination of discharge, along with a flow meter apparatus to measure the velocity of flow, the discharge in the Toon River on the date of the survey was estimated to be approximately $0.6m^3/s$. Two channel cross-sections were surveyed at the river; however, the Appendix to the draft report for this development which outlines the location of this survey and the details of the river channel flow modelling undertaken using the HEC-RAS river analysis system could not be located by staff of Malachy Walsh and Partners prior to the publication of this report.

3.2 Mapping

Where appropriate, the above datasets were compiled and mapped using ArcGIS software. These are presented in Appendix 4.

Maps presented are as follows:

1. Toon sub-catchment boundary
2. OSI Historic Six-Inch Mapping
3. ESB Property Boundary
4. SAC NPWS Designation
5. SPA NPWS Designation
6. NPWS Conservation Objectives extent for alluvial woodland
7. Historic origins of woodland within The Gearagh
8. OSI unrectified aerial imagery 1974
9. OSI Orthophotography 1995
10. OSI Orthophotography 2000
11. OSI Orthophotography 2005
12. DigitalGlobe Aerial Imagery 2012
13. Corine land use data 1990
14. Corine land use data 2000
15. Corine land use data 2006
16. Corine land use data 2012
17. Commercial Forestry
18. Soils
19. Subsoils
20. Bedrock/Geology
21. Upstream Windfarm Planning Boundaries
22. Hydrometric Gauge Locations
23. Lee CFRAMS Cross Section Locations
24. LiDAR Digital Terrain Model

4 Site Assessment

A preliminary site visit to The Gearagh was carried out by ESBI staff ecologist G. Hamilton on October 11th 2016, with a subsequent visit (accompanied by geotechnical engineer C. Brangan) on October 21st 2016. Mr Kevin Corcoran was met during the preliminary visit on the 11th to discuss the site and the objectives of the scoping exercise, but owing to other commitments, he was unable to personally accompany ESBI staff to direct them to specific locations of purported erosion or upstream channel modifications. Observations of the character of the Toon River at a series of locations upstream of the woodland were made during both site visits.

During the October 21st visit, the main wooded part of the site was accessed from the Inchigeelagh Road, close to the road junction in Raleigh South. The main channel of the Toon River was waded for approximately 1 km into the woodland, with a number of deviations being made to investigate the anastomosing channels branching off (both flowing and dry). Water levels during both visits were relatively low, following good periods of dry weather during October, facilitating relatively good access to the woodland.

General assessments of the alluvial woodland were made, including notes of any notable erosion and areas of sediment deposition, tree falls and debris dams, instream vegetation and islet soil composition and condition. A summary of the site visit observations is presented below.

Of primary note during the survey along the Toon River section of The Gearagh woodland is the relatively distinct character of the main channel compared to the anastomosing channels. The main channel is relatively steep-sided and gravel-bedded with close to vertical banks apparent along a number of stretches (atypical of the trapezoidal channel cross-section expected in anastomosing systems, see Section 2.7). Bare earth and exposed roots were sometimes visible on these steep bank sections. By contrast, the smaller branching channels on either side of the main channel comprised more sloped bank angles with less exposed root material and occasional carpets of liverworts, particularly on the less exposed east-facing sides of the constituent islets. There was a general absence of debris dams across the main channel, while these tended to be more frequent in the side channels.

A more intact anastomosing character of the Toon River only becomes apparent once the influence of the Lee becomes significant; this occurs south of Raleigh South, and is estimated in the map shown in Figure 4.1.

The more northern channel of the Toon River (shown on the OSI Discovery mapping as the main route of the river) comprises regular slow moving pools with comparatively deep silty sediment. Anabranching channels connecting the current dominant channel with this more northerly channel were often dry and displayed a build-up of sediment or gravels on the lee side of the islets.

While fallen trees with exposed rootplates were recorded along the main Toon channel, these were also frequently (if not more so) noted within the woodland to the north of the river. Apparently some local landowners have been known to engage in removing debris dams across the main Toon River channel with chainsaws, in order to reduce the flooding risk of upstream lands (K. Corcoran, pers. comm.).

Occasional specimens of the invasive Himalayan Balsam were noted in the northern portion of the woodland and along the banks of the Toon River just downstream of Toon Bridge. Several specimens were also noted along the Annahala causeway. While no extensive stands are currently present, there is potential for these to become established in the future with potential negative impacts to the extant native flora of the woodland and river corridor.

The main channel of the Toon River within the woodland was predominantly free of instream vegetation, with only occasional stands of water crowfoot with some starwort being recorded. Upstream of Toon Bridge, where stands of instream vegetation are known to become relatively dense, very little comparable vegetation was observed, indicating that such growth had relatively recently been removed from the channel. Instream vegetation was more apparent further upstream along the Toon, for example downstream of Coolcaum Bridge and from other vantage points along the river. Such vegetation was absent from the sections of the river where it rapidly descends down narrow gorges north of Clonshear More.

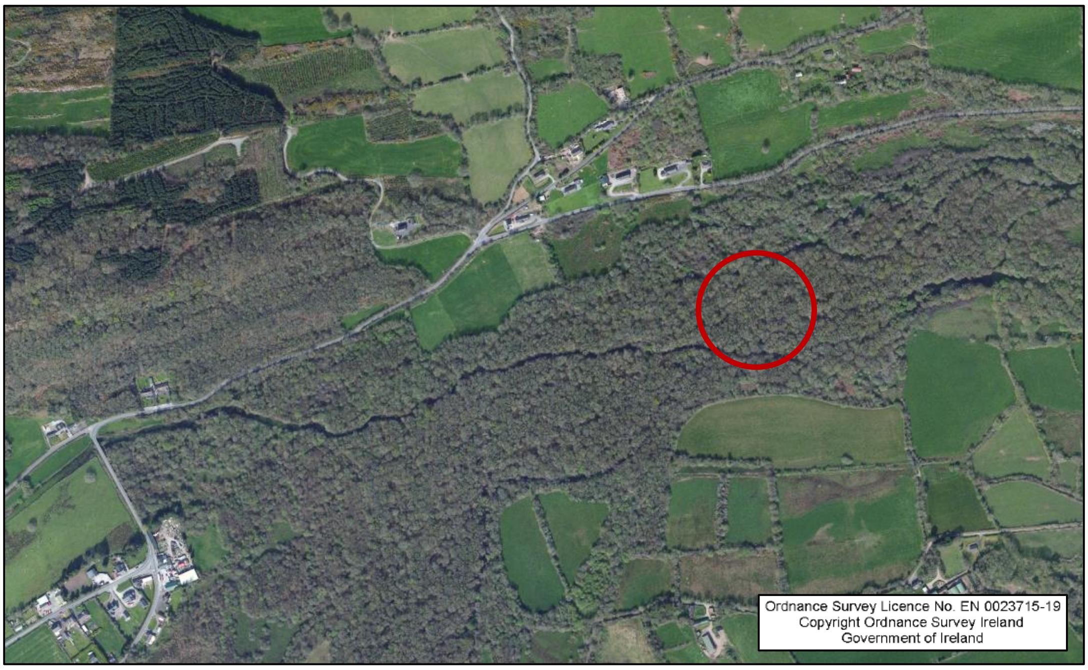

Figure 4.1: Approximate area within site where anastomosing character of Toon River becomes re-established

From a geotechnical perspective, in the absence of trial pitting, soil sampling or other intrusive investigations, only the exposed soils could be described based on a visual inspection. The material at the surface on the islands is a dark brown soft to firm organic slightly sandy slightly gravelly silt. A shear vane was pushed up to 300 mm into the soil and recorded undrained shear strengths of 50 to 70 kPa, consistent with a firm silt. The material visible at the bed of the wide channel of the Toon was a loose single sized gravel. Elsewhere, the bed material at the bed is a soft silt.

The appearance of the current main channel of the Toon River within the woodland (i.e. a steep-sided dominant channel with evidence of drying out or silting up of side channels) is obviously not the natural character for the river in this habitat, as is evidenced from the more diverse anastomosing features which occur along the Lee section of the woodland and where the Toon and Lee converge south of Raleigh South. However, attempting to extrapolate potential contemporary bank and islet erosion based on the current appearance of the site (in light of the likely extensive and severe damage that was done in the 1983/84 events) is extremely difficult. By contrast, it is more clearly apparent that the hydrology in the woodland to the north of the existing main channel has been negatively altered, with minor channels here silting up and being progressively abandoned by the river due to a fall in flow volume and regularity in such channels.

In relation to tree fall within the woodland and its relationship to erosion, it was the opinion of the geotechnical engineer that erosion is probably more likely to be the consequence of island breakdown following tree fall, rather than the river undermining the root system during strong flow events, subsequently leading to windthrow. Erosion scouring the edge of an islet could undermine the tree somewhat, but it expected that the root system would be quite extensive and act to stabilise the island as a whole, through trapping debris and compacting the component alluvial soil.

By contrast, any tree growing close to a bank will be less stable than a tree in the middle of an island. It may grow to a size and weight that the root system cannot support it and it will topple over. This will expose soil that could then be rapidly eroded away, even in relatively low flows. The tree becoming unstable because it grows too big seems the more likely cause of most tree falls on the banks of islands. It is worth noting that there are comparable amounts of fallen trees in the northern portion of the woodland where there has likely been reduced river power in recent years. However, it is conceivable that where the canopy has been opened up more along the extant dominant Toon River channel, that windthrow could be somewhat increased as the trees here may be somewhat more exposed to the prevailing wind.

5 Recommendations

5.1 Basis of recommendations

The scoping exercise has sourced evidence that the primary reason for the current morphology of the Toon River channel within The Gearagh woodland is likely to be as a result of a destructive event which occurred over 30 years ago. Attributing changes in appearance (exclusively or in part) to purported hydrological changes which may have occurred in the Toon headwaters in the intervening period is problematic without a reliable and continuous historic flow and depth data for the Toon River for the intervening period, which unfortunately is not available.

Regardless of the origin of the existing functional hydrology of the Toon River channel and its subsequent influence on the anastomosing channels to the north of the site, it can still be argued that there is ongoing potential for the artificially altered channel to be leading to systematic change in The Gearagh woodland. Such impacts are of considerable significance to the Conservation Objectives (see Appendix 2) for the alluvial woodland Qualifying Interest for the site.

However, any hydrological/hydromorphological impacts occurring along the Toon channel would need to be identified and quantified using a robust empirical monitoring regime with appropriate levels of control data from elsewhere in the woodland. It is not advisable to carry out any significant physical measures aimed at preventing or reducing erosion unless there is reliable quantifiable evidence of such effects, and clear geographic pinpointing of the location of any impacts; this should not be based on anecdotal evidence.

It is therefore proposed that a Management Plan be developed for the site, comprising a suite of measures aimed at facilitating the necessary monitoring.

5.2 Gearagh Woodland Management Plan

Measure 1: Delineate cross-sections within woodland to establish baseline habitat quality and monitor erosion

To facilitate an empirical assessment of any possible active erosion or deposition processes occurring within The Gearagh woodland, topographical cross-section surveys will be carried out at specific locations within the woodland. Ideally these will encompass both the dominant Toon River channel and some of the smaller channels parallel to the dominant channel.

Additionally, a number of control cross-sections will be established along the anastomosed course of the River Lee within The Gearagh woodland; these controls will be used to establish the natural rate of erosion within the woodland (the Lee is less dominated by a single channel when compared to the altered Toon River).

As these cross sections will be repeated for the purposes of monitoring potential changes in the channels, it is essential that repeat surveys are carried out at the same location with marked endpoints.

In taking measurements across the cross-section all significant breaks of slope will be marked to provide an accurate representation of any change. Surveys should be carried out initially on a quarterly basis and possibly directly after high flow events which could drive geomorphological change within the site.

Given the complex and relatively inaccessible nature of the site, setting up cross sections to be monitored will not be trivial. The cross-sections will need to sample a representative length of river within the woodland; it is estimated that up to 5 cross-sections would be sufficient for the Toon section of the site, with a further 2-4 sufficient for the control sections along the Lee channels. Fixed-point photographs at each location will be taken for subsequent visual comparison of the monitoring locations; these will be taken from specific reference trees adjacent to the river channels which will be marked and GPS-located.

Based on consultation with NPWS, the potential for including in-stream vegetation surveys (i.e. macrophytes, bryophytes, lichens and freshwater sponges) will also be considered as part of the survey design process, following further engagement with NPWS. ESB has indicated that it is amenable to funding such surveys, assuming that the associated cost is in line with expectations. There may also be the opportunity to include island vegetation surveys adjacent to the location of the cross-sections. Such data is valuable as the flora component of islands has the potential to be correlated to islet erosion and stability.

Measure 2: Winter canopy drone survey

A drone survey of the woodland along the Toon channel will be carried out during the winter months, to take advantage of bare canopy and elevated water levels, so active channels can be distinguished. This will provide a highly detailed baseline image of the site, against which further channel change or windthrow of trees close to the channel can be compared.

Measure 3: Establish localised erosion monitoring points

A passive monitoring scheme relating to potential erosion of bank and islet soils will be established through the use of ‘erosion pins’. With careful placement of such pins they can provide a good estimate lateral adjustment over time, and are an extremely economic approach. This is a simple technique that comprises of driving pins into the face of a river bank. While any material that will not decay is suitable, a small diameter metal pin is preferable as large pins may themselves lead to localised scour. The pin should be stable and perpendicular to the bank face. Pins will be of a sufficient length (minimum 1 m) to negate the risk of them becoming dislodged from an eroding bank face and washing into the river.

The section of the pin protruding from the bank is measured directly using a tape measure. This should be carried out periodically although, as outlined with previous techniques, a responsive approach should be adopted so that data is collected after high flow events. The deliverables are readings of the length of each pin that is exposed at each individual location at each survey date. This will provide an estimate of the amount of erosion that has occurred at the location between two sampling dates. A network of such pins could be established within the woodland, with their precise locations established via GPS to facilitate repeat surveys. Again, the monitoring network will comprise points along the dominant Toon River channel and some of the smaller channels parallel to the dominant channel, as well as a number of control points established along the anastomosed course of the River Lee.

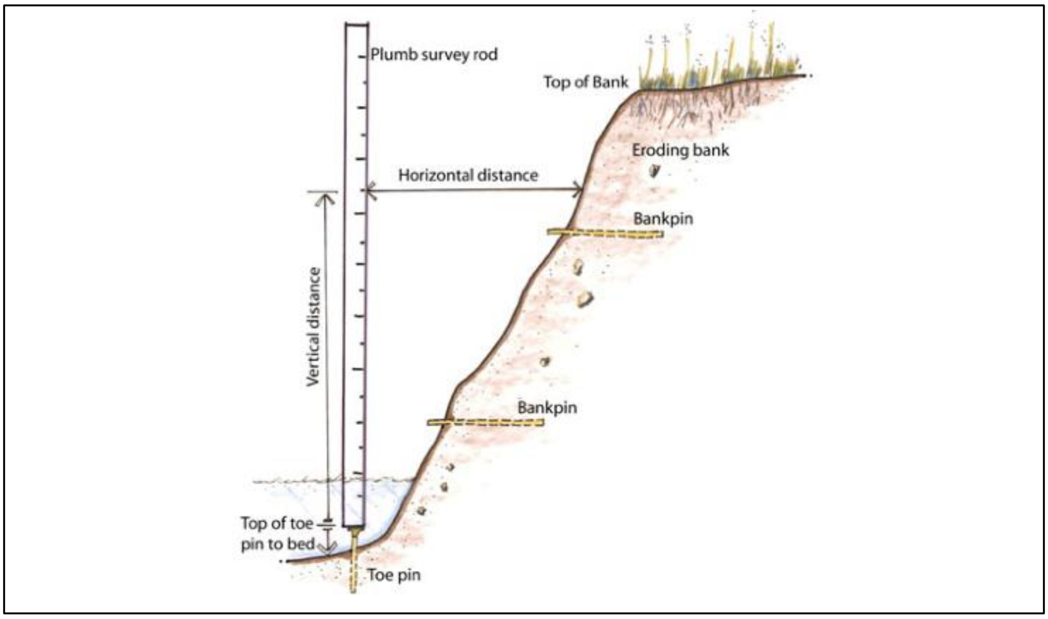

Figure 5.1: Erosion Pin Methodology

Measure 4: Monitor levels and flows at cross-sections

The compilation of continuous water level monitoring in the channels at the cross section locations will also be useful to relate fluvial and pluvial events with any recorded morphological changes. This will be achieved using passive data-logger probes installed at a series of points in the river within the woodland area. These probes are very robust and relatively inexpensive. Furthermore, the cross-referencing of collected data from these loggers with ESB data for levels at Carrigadrohid dam will enable an empirical assessment of the influence of the operational regime of the reservoir upon water levels within the woodland. Any buffering effects of discharge rates through the woodland arising from increased levels in the reservoir can then be elucidated.

The above measures will be coordinated by the primary landowner of The Gearagh, namely ESB, who would assume responsibility for the implementation of the initial monitoring phase (as recommended in Section 5.4) and the subsequent reporting of findings to a Management Plan Steering Group comprising the key stakeholders for the site.

In summary, it is envisaged that the above Management Measures will be able to empirically define the presence or absence of any erosive or other abnormal changes within the alluvial woodland of The Gearagh. If no such impacts are evident, it can be concluded that the targets for the Conservation Objectives of the Alluvial Woodland feature site are being achieved and no further measures will be necessary. If evidence of erosive impacts is found to be present, then a subsequent Management Plan will be developed with targeted measures aimed at reducing risk to the integrity and functioning of the Alluvial Woodland within the SAC.

5.3 Toon Sub-catchment Monitoring Regime

It is also proposed to develop a programme to collect and collate key data relating to the hydrological behaviour of the Toon River upstream, of The Gearagh. This will operate in parallel with the Management Plan monitoring within The Gearagh, thus facilitating the assessment of any causality between the fluvial behaviour of the river and any recorded habitat change within the woodland.

Based on initial correspondence with the Environmental Protection Agency (EPA) and the Office of Public Works (OPW), it appears possible that the EPA would be in a position to carry out the required upstream monitoring activities and subsequently supply the relevant data to the ESB as part of the Management Plan monitoring analyses. It is envisaged that the upstream monitoring would comprise the following actions:

Replacement and re-activation of Toon River Hydrometric gauge

The inactive staff gauge (located just downstream of Coolcaum Bridge, See Appendix 4, Map 22) should be replaced with an automated flow and depth monitoring gauge. This will facilitate the development of an accurate record for the behaviour of the river under different weather conditions, and should allow comparisons with other rivers in the region during specific time periods.

Comprehensive cross-sectional survey of Toon River

Surveys across width of Toon River upstream of The Gearagh woodland at least every 1 km. This will allow the development of a hydraulic model for the river and an assessment of its erosive potential under different flow conditions.

Measurement of channel cross sections is taken across the width of the channel in a single line perpendicular to the flow. The survey may extend beyond the immediate channel width to include features such as terraces or embankments. In determining the location of cross sections it is useful to look for (adapted from Harrelson et al 1994):

- A straight section between bends
- Riffles
- Meander bends
- Clear indicators of the active floodplain or bank-full discharge
- Presence of terrace(s)
- Channel form typical of the river
- A reasonable view of geomorphological features

If feasible, these studies should also encompass an assessment of extant sediment on the substrate of the Toon River immediately upstream of The Gearagh.

5.4 Period of monitoring

It is envisaged that a minimum of 2 full years of monitoring data collection will be required to fully determine baseline conditions, though it is conceivable that more time might be necessary should climatic conditions during this 2-year period result in atypical hydrological conditions within the site, such as exceptional rainfall, storm or drought events, which might result in the need to re-establish the baseline condition of the site. The EPA hydrometric gauge re-installed on the Toon River (as outlined in Section 5.3) should be left in place and kept operational indefinitely.

5.5 Output data usage - Fluvial geomorphological assessment

Only once an appropriate degree of monitoring data has been collated (as outlined in Section 5.4) can a scientifically robust fluvial geomorphological assessment (as recommended by Jervis Good, NPWS, see Appendix 5) of the Toon River within and upstream of the woodland be carried out. This is likely to better inform the current status and risks to the woodland.

5.6 Conclusion

In summary, it is envisaged that the above measures in Sections 5.2 to 5.4 will be able to empirically define the presence or absence of any erosive or other abnormal changes within the alluvial woodland of The Gearagh. If no such impacts are evident, it can be concluded that the targets for the Conservation Objectives of the Alluvial Woodland feature site are being achieved and no further measures will be necessary. If evidence of erosive impacts is found to be present, then a subsequent Management Plan will be developed with targeted physical restoration measures aimed at reducing risk to the integrity and functioning of the Alluvial Woodland within the SAC.

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