An Chomhairle Oidhreachta
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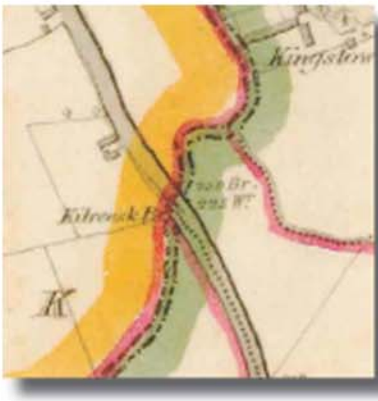

Historic Road Bridges

Fingal County Council

A study prepared by

JOHN CRONIN & ASSOCIATES
ARCHAEOLOGY | CONSERVATION | HERITAGE | PLANNING

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ATKINS

Volume 1
Main Document

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Executive Summary

This study set out to provide a comprehensive set of information on each of fifteen bridges chosen as a representative sample of these historic structures in the Fingal County Council area. Each bridge was surveyed by an ecologist and a built heritage expert with the survey data and desktop derived research and information compiled in the inventory which forms Volume 2 of this study. A context to the information is provided in this volume with the background to historic bridges in Ireland focusing on the study area as well as discussion of the ecological nature of bridges and their associated habitats. There is further discussion of the built and ecological heritage issues affecting conservation and ongoing maintenance of bridge structures which culminates in general and specific recommendations for their repair and the necessary steps which must be taken while carrying works out to ensure compliance with legislation and best practice.

Whether this study is used as a template for a further limited survey or the format developed here is rolled out to encompass the full stock of historic bridges in the Fingal County Council area, it is considered that field survey is best carried out at least with the expertise of both a built heritage expert, conservation experienced engineer or architect and an ecologist. It was felt that the combination of these disciplines provided comprehensive recording of the issues relevant to conservation of historic bridges and having two such experienced personnel on surveys provided a good opportunity to discuss items that could be overlooked by a single recorder.

Acknowledgements
The authors of this report wish to thank Fingal County Council for commissioning this report and in particular Ms Helena Bergin, Conservation Officer (Acting), Mr. Gerry Clabby, Heritage Officer, and both Ms Mairead Phelan, Senior Engineer, and Mr. Ray Llewelyn, Senior Executive Engineer, in the Road Transportation Structures Section. Mr. Mervin Hamilton of Waterways Ireland provided useful research for the Canal Bridges within the survey set.

The contribution of Mr. Pat McAfee, the eminent mason and expert in the field of historic stone structures was greatly appreciated both for his thoughts and advice on repair issues associated with historic bridges and the sections referenced herein from his forthcoming book on Irish Stone Bridges.

John Cronin
May 2009

1. *Introduction*

In September 2008 John Cronin & Associates and Atkins were commissioned by Fingal County Council to undertake a study of a selection of fifteen historic road bridges. The project aims to provide baseline information on the fifteen bridges within the functional area of Fingal County Council and to provide an assessment of their significance. The results of the project are to provide the basis for the appropriate management of these bridges into the future. The specific aims of the study are as follows:

- Undertake a desktop review that collates and consolidates existing information on the bridges within the study
- Assess the natural and built heritage significance of the bridges
- Produce a plan that recommends conservation and maintenance measures for the bridges which will provide the basis for short and long term remediation works and an annual maintenance programme
- Prepare a supporting photographic survey of the bridges

The inventory is contained in a separate document (Volume 2).

The fifteen bridge structures within the study area are situated upon 5 different watercourses including the Delvin River, the Ballyboughall River, the Broadmeadow River, the Ward River and the Royal Canal. Many of these watercourses, together with their riparian habitats and associated structures including bridges, provide valuable wildlife corridors and refuges for wildlife in areas of intensive agriculture and human activity. One objective of this report is to assess the ecological value of each of these fifteen bridge structures to wildlife in the locality whilst providing a general overview of bridge ecology. Recommendations on measures to safeguard the natural heritage value of bridges during maintenance works are also provided.

2. *Methodology*

The objective of this report is to assess the built heritage and ecological value of each of fifteen bridge structures selected by Fingal County Council. The 15 bridges included in this study are listed below.

Table 1: Bridges Assessed.

Bridge number	Bridge Name
1	Gormanstown Bridge
2	Old Mill Bridge
3	Garristown Bridge
4	Cockles Bridge
5	Oldtown Bridge
6	Ballybougall Bridge
7	Lispopple Bridge
8	Roganstown Bridge
9	Mack's Bridge
10	Ballymadrough Bridge
11	Knocksedan Bridge
12	Chapelmidway Bridge
13	Kirkpatrick Bridge
14	Callaghan's Bridge
15	Collins Bridge

Methodology - desk study

Initially, it was decided to create a system of bridge numbering which could be used as a template for cataloguing the structures in future. This system was developed to allow a concise reference to be given to each bridge structure within the Fingal Historic Bridge Survey (eg. FHBS01 (Gormanstown Bridge)) that could be indexed to the inventory of bridge information and could also be incorporated in the naming of images in the accompanying photographic record (eg. FHBS-01-BH-01 (Built Heritage image 01 for Gormanstown Bridge) with the image caption in the inventory). This numbering system has been used throughout the report to avoid the inconsistencies of previous numbers used by various bodies and bridge names which can change over time.

For the built heritage study, there was a review of all the relevant literature on historic bridge structures in Ireland which included publications on the development and history of the structures generally, some of which focused on the more significant individual bridges on Fingal survey list. A richer source of published information was available on the actual roads which were initially routed towards specific crossing points or bridges and which later (from the late eighteenth century onward) became more directly aligned as bridge construction expertise allowed obstacles to be crossed wherever a route intersected them rather than the route being determined by location of the easiest bridging point. Information on the history of construction of the Royal Canal also included some detail on the bridges which crossed it.

The other major source of evidence for historic bridges was the various cartographic representations of the study area available from William Petty's Down Survey maps of the late seventeenth century through subsequent historic road maps, the early Ordnance Survey maps and up to the present O.S. representations. While it was not possible to verify the representation of the existing structures on historic maps (bridges are often re-built on the same site), these are still useful sources of historic evidence for the actual crossing point and occasionally the form of the larger bridges was depicted on the map.

The records kept by the various owners of bridges on the survey group were investigated but these were limited to the County Council's record of protected structures information and engineering reports on a number of the structures dating to the early 1980s. Limited information was available from the National Inventory of Architectural Heritage which had covered most of the structures and a few bridges were described in the archaeological inventory of County Meath.

The built heritage and archaeological designations of each structure were verified with the relevant bodies (Local Authority and Department of Environment, Heritage and Local Government)

For the ecological study of bridges, a desktop review was carried out in order to identify the presence of sites of conservation importance; including proposed Natural Heritage Areas (pNHAs), candidate Special Areas of Conservation (SAC), Special Protection Areas (SPA) or any non-designated sites of ecological interest. A review of the published literature was undertaken to collate data on species and/or habitats of conservation concern within the vicinity of the bridges proposed for survey. As part of the assessment process, consultation was undertaken with appropriate individuals and statutory and non-statutory organisations such as the National Parks and Wildlife Service (NPWS) of the Department of the Environment, Heritage and Local Government (DoEHLG), Eastern Regional Fisheries Board (ERFB), Fingal County Council Biodiversity Officer, Waterways Ireland, Bird-Watch Ireland (Banagher) and Brian Keeley (Bat specialist). Responses are integrated into the text below as appropriate.

Methodology - Field Survey

Field study by built heritage recorders and ecologists was done largely in tandem and involved description and assessment of the built heritage and ecological features associated each site in addition to collecting photographic records of each bridge as well as associated structures and features.

Built heritage survey involved description of the form and configuration of the bridges, and assessment of their structural and material condition. The extensive photographic record collected during field survey enabled detailed inspection of various elements of the bridge structures as part of the desk-based analysis.

The methodology of this project involved assessing and describing the ecological features associated with 15 bridges in the Fingal study area in addition to collecting photographic records of each bridge and associated structures and features.

The ecological assessment of each of the fifteen bridges involved an ecological survey and assessment of each bridge and its environs (i.e. associated watercourse, riparian and adjacent habitats):

- Assessment of the suitability of the bridge and surrounding roosting opportunities to support birds. This included identifying suitable crevices within the bridge structure and identifying any nearby nesting opportunities, including mature tree species and cover of Ivy at each bridge.

- Assessment of the suitability of the bridge and surrounding habitats to support bats. This included identifying suitable crevices within the bridge structure, identifying any nearby mature tree species in addition to assessing the percentage cover of Ivy at each bridge in order to the roosting potential for bats.

- Assessment of Otter activity in the vicinity of the bridge and surrounding habitats. Field evidence for Otter activity included Otter spraints or footprints within the bridge's environs.

- Suitability of the bridge and surrounding habitats to support other mammals. This included identifying mammal footprints and droppings.

- A botanical survey of each bridge structure. All plant species growing upon the bridge structure and associated side walls were noted. The percentage cover of Ivy was also assessed as this was deemed to be useful to ascertain bird and bat potential and to have implications for bridge structural integrity. Riparian habitats adjacent to the bridge structure were also assessed and characterised according to the Heritage Council classification system (Fossitt, 2000).

- Assessment of the characteristics of each watercourse associated with each bridge to provide information on potential use by aquatic fauna. This included assessing characteristics such as the percentage sand, gravel, cobble and boulder within the rivers substrate. Other watercourse characteristics such as the percentage riffle, pool and glide habitats within each watercourse and a visual determination of issues with respect to water quality were also assessed.

It should be noted that the ecological assessment of each bridge is the result of one field survey supplemented by the desktop review. Therefore, the ecological assessment cannot be considered comprehensive.

Following the on-site built heritage and ecological evaluation of each of the fifteen bridges, guidelines for the conservation of built and natural heritage during maintenance works were developed in discussion with archaeologists and structural engineers. These included key points to guide those responsible for the bridge structures, including details of statutory regulations and consents necessary for bridge works, and specific areas of attention required for each bridge.

A detailed survey was carried out by an experienced engineer of two bridges chosen to represent the greatest number of potential repair issues which those responsible for bridge maintenance could face. The findings of this survey were incorporated into section 4 below.

Following the on-site ecological evaluation of each of the fifteen bridges, guidelines for the conservation of natural heritage during maintenance works were developed in discussion with archaeologists and structural engineers. These included general guidance, including details of statutory regulations and consents necessary for bridge works, and detailed guidance for each bridge.

3. *Irish bridges: a historical overview*

Bridges, more than any other architectural feature, become an integral and almost naturalised part of the countryside with many older bridging points creating the very reason for the existence of the settlement around them. The design of many of the smaller road bridges (almost invariably built of stone) has been refined over generations with their generally simple, robust construction in local materials by local masons. Variations occur in bridge design where the width of the span, angle of the intersecting road and watercourse and topography of the surroundings were dealt with on a site-by-site basis, with more standardised constructions appearing where associated with railways, canals or channelised river drainage schemes. While several bridges have been enlarged or altered to cater for modern needs, many of these structures have been unaltered and are still in regular use carrying loads which far exceed any that could have been envisaged when they were constructed.

Influences on the historical development of bridges and roads in Ireland

By their very nature, bridges form integral links in the transportation networks essential for a community's social and commercial success with the strategic importance of many more significant bridges resulting in them becoming a focus during conflicts. Additional features of important bridges are often the construction of adjacent structures to protect and administer their use and the growth of communities around the bridging site. Prior to the construction of the vast number of bridges that exist today in Ireland, most communication over waterways would have been by use of natural or man-made fording points, occasionally accompanied by clapper bridges which comprised stone slabs or beams spanning a number of narrow archways between rubble piers to create a narrow, dry crossing over a shallow part of a river. For larger spans, ferry boats or rafts would have been the only options. The arrival of the Cistercians and later the Normans in the twelfth century to Ireland saw the introduction or refinement of the art of stone arch construction, a technique which marked the success of Norman expansion at this time with its obvious benefits for architectural structures such as the formidable keeps and for the bridges which improved the efficient transport of goods from the rich agricultural areas to the centres of population. While the Anglo-Norman influence on bridge construction declined after about 1350 with the break-up of the manorial system of government, the introduction of the technology and quality masonry techniques had a lasting contribution to this element of landscape architecture when later road-building programmes were enacted.

Agrarian reorganisation with reclamation of upland and more remote areas of farmland as well as the greater proliferation of individual rather than clustered farmsteads resulted in creation of the characteristic, tight network of rural Irish laneways or *bóthríní* from the early eighteenth century (Aalen et al. 1997). These were usually constructed by a local landlord for the purpose of improving communications for his own business interests, but the Highway Act of 1613-15 also placed responsibility for upkeep of the roads on parishes to administer the participation of property owners in six days of road maintenance every year in early summer under the statute labour system. A later act of 1634 sought to finance valid applications from baronies for the more costly repair of "bridges, causeys and toghers" through levy of rates by the county-level Grand Juries which would reimburse the cost of works to local landlords if the works were approved (Cox and Gould 2003). The loss of Grand Jury records during the Civil War in the early 1920s has made the dating of un-marked bridges originating in the seventeenth and eighteenth centuries difficult and while crossings are occasionally marked on historic maps, there is no assurance that the structure present today is not a later bridge on the same site.

Many of the smaller roads constructed under the statute labour system were aligned around geographical features or demesne lands and to keep costs to a minimum, the simplest bridging points of rivers would be chosen for crossings even if this meant directing the road off the straightest route to its intended destination. Turnpikes were created in Ireland from 1729 in order to finance the repair or construction of roads through tolls collected along the routes or by bridge-masters at major river crossings. These and other new roads originating from the eighteenth century were often of very straight alignment, being designed by engineers as a complete project as oppose to the traditional methods of ground based survey of routes which often skirted around the demesnes of local landlords and avoided poorly drained or hilly areas. With roads following surveyors' direct alignments, bridges were more likely to cross rivers and other obstacles at acute angles, leading to more complex, longer structures with skewed alignments and often more substantial approaches and abutments. Turnpikes also had standard widths stipulated in the various Turnpike Act of 1729-1856, which probably resulted in the replacement or extension of many narrow medieval bridges to comply with the initial twelve foot minimum and the subsequent fourteen foot standard width (Rynne, 2006). The turnpikes continued to operate until 1857 when the competition of the growing railway network made them unviable.

Figure 1: Irish Turnpike acts passed before 1805 (after Andrews 1964) (taken from Rynne 2006)

Later road construction projects followed surveys such as that of the Postmaster General between 1805 and 1811 from which, more direct routes with specific standards of gradient were built, notably the present N2 between Dublin and the eighteenth century planned town of Slane. While the roads leading from the central industrial and commercial node of Dublin were mostly constructed by the mid to late eighteenth century, poverty relief schemes on foot of harvest failures and economic depression in the post-Napoleonic era saw a doubling of Ireland's wheeled vehicle roadways, particularly in the most distressed western counties in the early to mid-nineteenth century. From 1822, central government made grants to the Grand Juries for specific road and bridge construction and government engineers were responsible for many projects throughout the country with the Irish Board of Works also making a major contribution to development and repair of roads and bridges from its establishment in 1831. Later the Congested Districts Board supervised the completion of further minor roads to stimulate economic development in the poorest western regions around the turn of the twentieth century.

Factors affecting bridge construction

Being costly items to construct, requiring significant engineering knowledge and often a design scheme which has to be refined to suit the particular geological and topographical characteristic of the individual bridging site as well as the variations in flow of the watercourse they span, bridges were historically more prevalent in the main areas of economic activity. This resulted in greater concentrations of bridges in the south and east of the country where the best agricultural land was concentrated and also around the economic centres such as Galway, Limerick, Cork, Youghal, Waterford, Wexford, Dublin, Drogheda and Belfast. The proliferation of good quality limestone in the central basin of Ireland with areas of basalt in the north east and old red sandstone along the south and south west coasts must have some bearing on the large number of stone bridges in Ireland as distinct from other regions where good building stone is less freely available. Prior to the introduction of significant expertise in stone building and for some time after, timber structures, initially based on trestle or wicker hurdle designs were common means of spanning watercourses and valleys. Clearly, these did not have the same properties of longevity of more robust stone bridges, which accounts for the limited evidence of historic structures in timber but the supports and other elements which would have been beneath the waterline have survived for study in a few cases thanks to the anaerobic conditions under the water. It is assumed that iron nails and reinforcing straps would have been part of the more permanent timber bridges but many were probably erected for temporary use or at least did not survive the rigours of their river sites for more than a few decades. In areas where experienced stone masons were at a greater premium than good quality timber or carpentry skills, timber decks and beams were erected between stone abutments and piers with such arrangements being used until as recently as the mid-twentieth century before the need for crossings of higher load capacity made the use of timber structures prohibitive.

The following translations adapted from O'Keeffe's 2001 publication on early development of Irish roads detail the Irish language terms used to describe various bridge forms and this can be useful while carrying out place-name research for specific structures:

Cesaig droichead – wicker bridge
Cliath droichead – hurdle bridge
Clár droichead – wooden bridge
Cloch droichead – stone bridge
Droichead clochaeltra – bridge of stone and mortar
Droichead long – bridge of boats (ferry crossing)

While there are many more small water-courses in Ireland than those large channels like the Shannon or towards the mouths of major rivers, the frequent heavy rainfall can cause dramatic fluctuations in water levels with fairly regular, damaging floods even on small rivers. This has resulted in the destruction and sometimes continual re-building of many bridges and arterial drainage schemes, mostly from the mid-nineteenth to the mid-twentieth centuries sought to regulate the flow of water and reduce the damaging effects of floods on crossings. Several rivers were straightened or channelised to aid the removal of flood water from flash-point locations. Where this was carried out on a larger scale, bridges along parts of the drainage basin subject to improvement schemes were sometimes re-built with wider spans, higher arches or they were skewed to straighten the river channel underneath a road. Pointed or rounded cutwaters were often enlarged or added to bridges in an attempt to reduce the build-up of debris which could impede the flow of water and cause particular damage during floods. The mid-twentieth century saw increased use of concrete casing to protect the lower parts of bridge structures and also paving of the river bed beneath the bridge, again usually as a retrospective measure to improve and aid the flow of floodwaters.

While many bridging locations have remained the same for centuries, the vast majority of the existing twenty five thousand or so structures spanning more than two metres date from after 1775 and many of these have been extended, widened or reinforced since construction. The school of bridges and highways in Paris had a strong influence on the scientific advances in bridge building throughout Western Europe from 1780 onward and while much control of bridge design for smaller projects was still in the hands of the master mason in charge of the site, the international standards being developed would have increasingly contributed to the design.

The vast majority of existing road bridges dating from before the mid-nineteenth century have stone arch construction with segmental-headed openings. These have developed from the twelfth century semicircular arches with pointed segmental arches following later and the three-centred or elliptical arch originating in the sixteenth century. Over time, the need for greater headroom lead to increased use of false elliptical arches for use on railway and canal bridges. The arch forms typologies of stone bridges are discussed in *figure 2* below taken from O'Keeffe (2001):

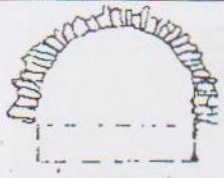
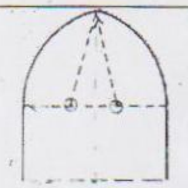
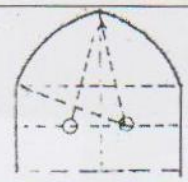
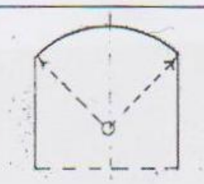
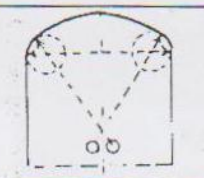
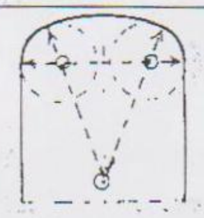
Type	Shape of Intrados	Comment
A		Semi-corbelled arch with the projecting stones tilted progressively until they become radial about half-way up on the curve; found in Irish Romanesque stone-roofed churches, such as St. Columba's (Kells) and in several bridges including St. Mary Magdalen's,* Mabe's,* Monks.*
B		Pointed segmental arches with the centres of the segments located on the intrados base line or span are common in church architecture and are sometimes described as ogives. Where r+span, it is called equilateral; $r={}^{4}/_{5}$ span, a five point; $r={}^{2}/_{3}$ span, three point or drop arch. They are often found in old bridges in France. The only examle found here so far is the central arch in Buttevant Old Bridge.
C		Ordinary pointed segmental arches have the centres, sometimes called striking points, located below the intrados base line commonly on the river bed. The curves spring from "skewbacks", that is sloped sotnes at the pier tops. Common in Ireland before 1450. Many examples are described in Part II, e.g. Slane, Askeaton, Adare, Trim, Babes.
D		Segmental arcs less than a semi-circle were rare in medieval bridges. Several early examples were found, e.g. King John's, Newtown, Athassel and are described in part II. All have span-to-pier ratios less than about 1.5. There are numerous examples form the 16th and 17th centuries which have arcs that are almost semicircular. Flat arcs and thin piers are common after 1750 when the theory of balancing the horizontal thrust came to be udnerstood.
E		The Tudor or four-centred arch originated in the reign of Henry VII (1485-1509). Good examples, described in Part II, are found in Ballinasloe Bridge (erected c. 1570) and Askeaton. I twould appear that the Tudor gradually evolved into the three-centred by merging the radii of the larger arcs on the vertical axis through the crown.
F		The three-centred arch is said to have orginated in Italy c. 1575. The earliest example found in ireland was the first Essex Bridge erected in 1676. Known as Anse-de-Panier, or basket handle, in France. Variations include the oval composed of a number of arcs of circles of an odd number with radii increasing from the springing to the keystone. A few bridges were found with true semi-elliptical curves, e.g. Avoca*. Became very common in the 18th and 19th centuries mainly to reduce the road gradients as spans increased. South Gate Bridge* (Cork) and Quoile* (Northern Ireland) are early surviving examdples.

Figure 2: Typologies of bridge arch forms or intrados curves on Irish bridges, 800AD – 1830. (Taken from O'Keeffe 2001)

Developments in use of iron for structural purposes, although more limited in Ireland than Britain due to the high cost of imported materials, lead to extensive employment of masonry piers and abutments supporting iron spans particularly for railway crossings. Examples in and around Fingal include the lattice girder sections of the Boyne viaduct and railway bridge and the Obelisk Bridge near Drogheda or the wrought iron bridges on the railway line at Rogerstown, Gormanstown and Laytown which replaced timber structures in the 1880s. Fully metal structures, either of cast iron or steel suspension design became more popular throughout the nineteenth century for pedestrian and significant bridges in cities such as Dublin's Ha'penny Bridge and Sean Heuston Bridge, examples like the Birr and Kinnity suspension bridges constructed on private lands or railway structures including the 1851 Athlone Rail Bridge. As reinforced concrete structures became more refined from the turn of the twentieth century, their adaptability for use in crossings of varying proportions, predictable load capacity and vastly lower requirements of time and masonry skill in construction lead to them become the dominant form of bridge for most modern road and rail use.

Canal bridges

In contrast to the early development of road networks which was supervised and planned locally, Ireland's canal network was constructed and developed under central government responsibility from the earliest works. Commissioners were created with the power to raise private money in their counties for the canal schemes proposed under a 1715 act with the aim of charging tolls on commercial use of the waterways when they were completed. Later in 1729, another act enabled the taxing of some luxury goods to fund the navigation projects of the four provincial commissioners and work to build the Royal Canal commenced in 1789. By 1817, the Royal Canal extending from Dublin to the Shannon was completed and as its route passed from the north west of the city towards the docks, a large number of roadways and streets were bisected by the canal, necessitating construction of several bridges in very close proximity to each other. One of the major elements of the Royal Canal's construction and one of its most costly sections to navigate was the cutting through the limestone quarries at Carpenterstown near Clonsilla (Clarke 1992 pp. 29, 44). Almost one quarter of the final cost of this section was spent on gunpowder and equipment for cutting through the rock but material from here was used for building many of the locks, banks, harbours and bridge structures at the Dublin end of the canal and the bridges were subsequently named after various directors and investors in the Royal Canal Company. Bridges on the canal were often of a standard design where stretches of the waterway were supervised by a particular engineer and they frequently had plaques on both sides of the parapet walls detailing the bridge name, date of construction and the supervising engineer. Richard Evans, an engineer experienced in the works to construct the Grand Canal, Barrow and Boyne navigations was involved in the section of the Royal Canal subject of this bridge survey (Delany 2004 p. 100). In 1847, the Midland Great Western Railway with the engineering services of William Dargan purchased the Royal Canal and utilised parts of the corridor cut by it through the west Dublin suburbs to locate its line west to Galway running parallel and alongside the Canal at several points (Popplewell 1987). The success of the railway and later the massive expansion of road transport spelled the decline of the canals here and elsewhere in Ireland although they had never attained the level of commercial success of some English canals which were better routed to carry mineral reserves to major centres of industry and manufacturing.

Historic mapping showing bridges

William Petty's Down Survey of 22 of the 32 counties of Ireland accompanied a Civil Survey which discussed the items portrayed on the map (see *figure 3* below). The Down Survey has few named bridges marked and roadways can only be deduced from the symbols marking of some bridge crossings and fording points. Used in conjunction with later maps, the Down Survey provides the first recording in many cases of a bridge at a particular site so its value for historic research is clear (O'Keeffe and Simmington 1991).

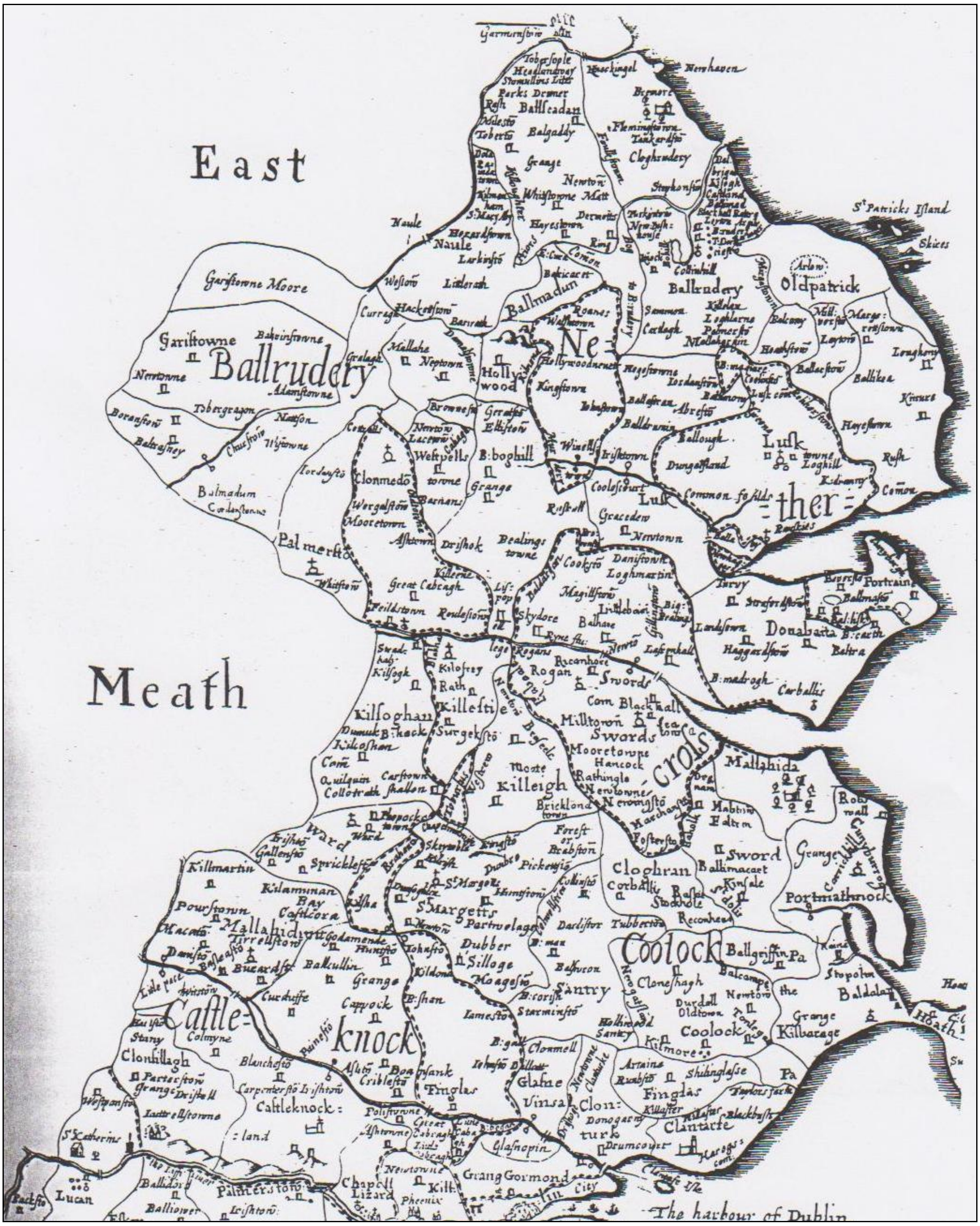


Figure 3: Extract of Down Survey for area north of Dublin (taken from O'Keeffe and Simmington 1991)

Henry Pratt's "Map of the Kingdom of Ireland" in 1702 and the subsequent map by Herman Moll in 1714 (see *figure 4* below) are the most detailed early maps of the roadways of Ireland. Again, Moll's map has only a small number of bridges specifically named but the crossing of roads over rivers is identifiable and this can be cross-referenced with later surveys.

Figure 4: Extract from Moll's map of the area around Dublin (taken from O'Keeffe and Simmington 1991)

John Rocque surveyed parts of Ireland at national, county and barony level and his maps provide useful evidence for original road routes, particularly in the Dublin area published in 1762. Few bridges are named but crossing points are recorded which can be a useful tool in the historic research of these structures.

Taylor and Skinner's 1778 roadmaps (see *figure 5* below) also indicate whether or not a bridge existed at a point on the eight thousand miles of principal roads mapped, however many of the smaller watercourses which roads traversed are not illustrated so some caution is necessary before drawing overall conclusions about all bridges.

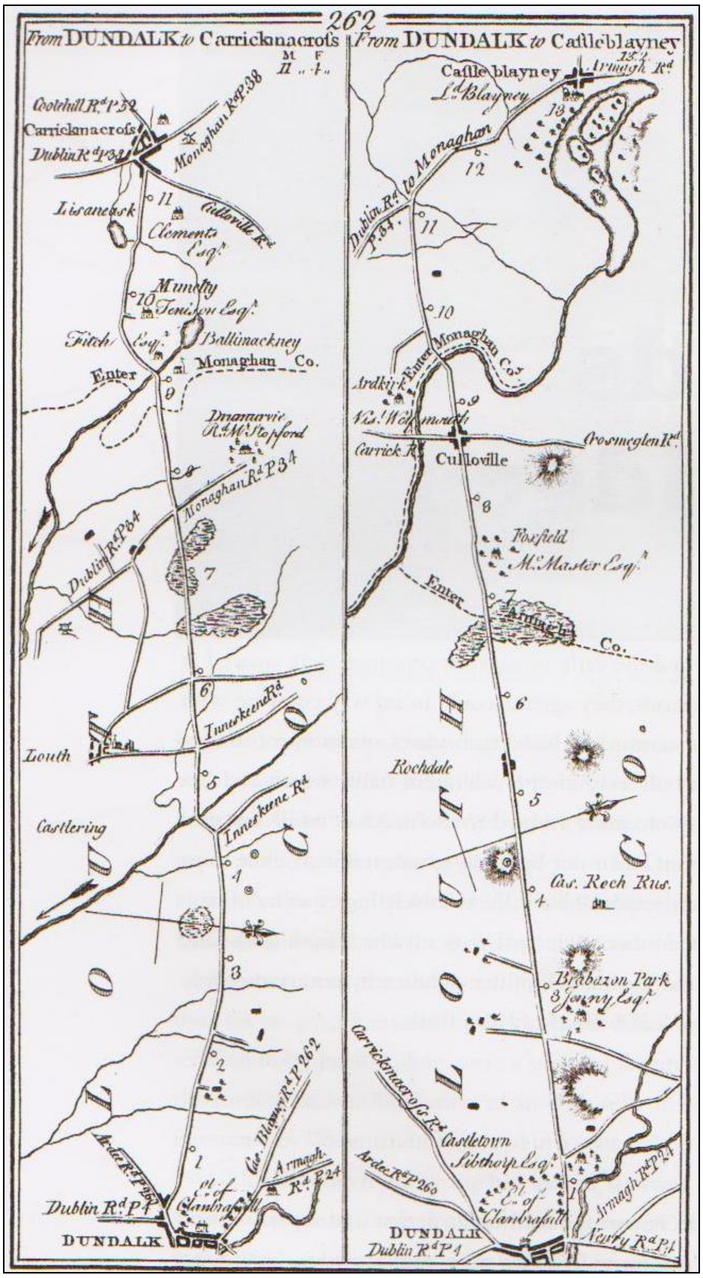


Figure 5: Extract from Taylor and Skinner road map (taken from Rynne 2006)

The baseline for researching the historic site of bridges is the first edition Ordnance Survey six-inch maps surveyed and published between 1829 and 1842. These are the most accurate early nineteenth century cartographic records of all areas of Ireland and they often depict the actual plan form of individual structures where they were large enough to be shown. Many of the bridges are also named on this map series and while the presence of a bridge on the O.S. map does not confirm the age of the existing structure at that site, it is nevertheless an invaluable record of the location and form of many crossings.

Their great numbers on the landscape and the consideration by many that they are mundane and unremarkable aspects of Irish architecture when compared with the medieval castles, Georgian houses or even industrial buildings has resulted in few bridges having any significant level of historic records. While their location can be pin-pointed on various historic maps, the age of the present day structure cannot be judged from these sources. Many of the records of the Grand Juries, and Board of Works did not survive the destruction of the Civil War and remarkably few plans of engineer designed bridges for the Royal Canal remain for research. One insightful source of eighteenth and nineteenth century bridges can be the Office of Public Works annual reports on drainage schemes (O'Keeffe 2004).

Fingal

Its location, just north of Dublin, the major commercial and transport node in Ireland since the early medieval period, has meant that Fingal is well represented in the range of historic maps and has also been generously served with transport links between the capital and the significant towns of Dunleer and Navan, ports of Drogheda, Dundalk and Newry and the historic industrial north eastern region of Ireland. As in the rest of the country, development of canals and railways along with road improvement and drainage schemes in the eighteenth and nineteenth centuries resulted in a large increase in numbers of bridges in the area north of Dublin covered today by Fingal County. Such scales of expansion have not been seen in Fingal since the nineteenth century until the recent major developments of national routes seen in the last decade.

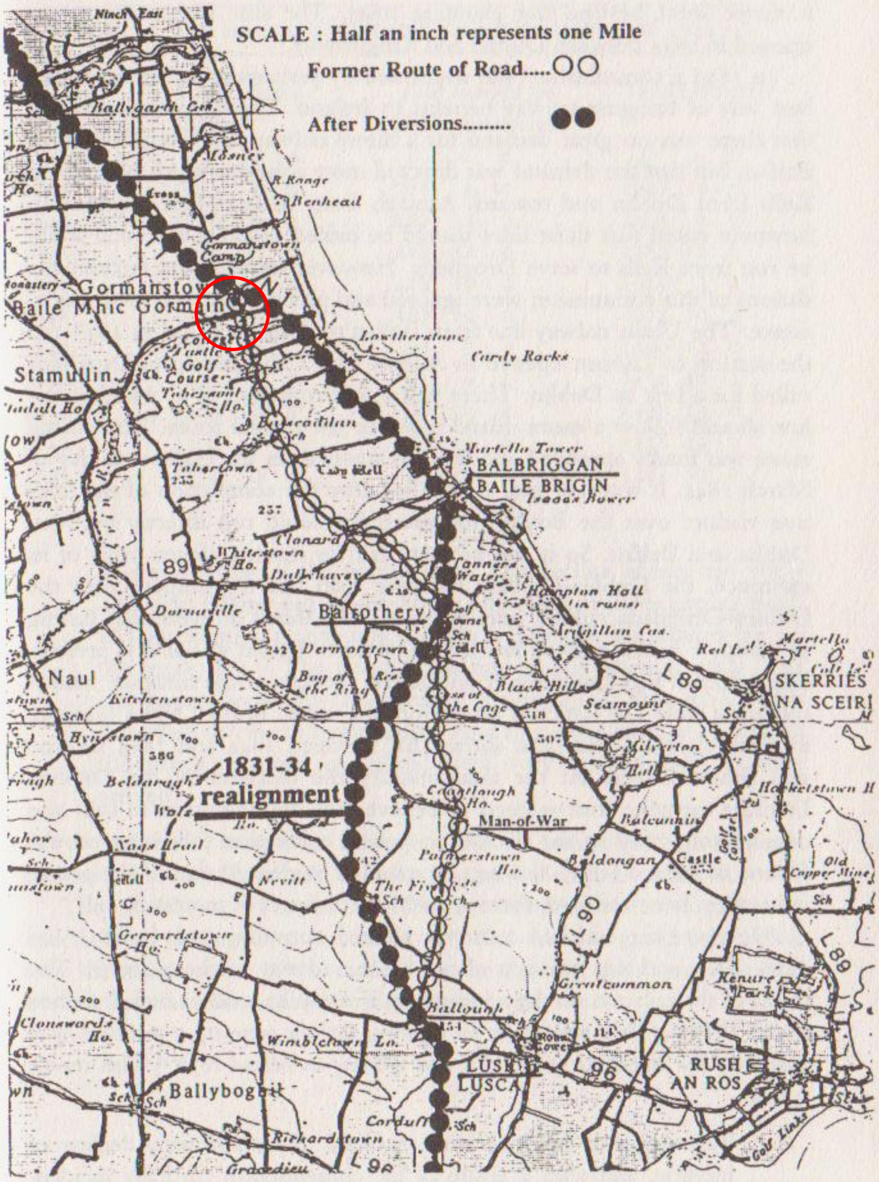
As with most roadways in Ireland, many of the records documenting the historic development of individual Fingal roads and their associated structures such as bridges were destroyed following the burning of public records in the Four Courts in Dublin in 1922. Those records that remained elsewhere have left a fragmentary account of the official works to various roads including those surveyed as part of this study. In terms of information on individual bridges in the Fingal study region, inferences must be drawn from research done on the development of the roads these structures carried or canals they cross, in the absence of many specific details about the bridge structures themselves.

With the network of rivers between the Liffey and Boyne, the initial settlement of the area would have been focused along the only available routes through the Neolithic forested landscape which were these navigable waterways. As economic development proceeded with the growth of religious houses and later, following building of settlements resulting from various invading forces, communication between these points was required across land as well as by sea. Between the fortified towns of Drogheda and Dublin, many settlements grew at river crossings and rest points along the mainly north-south orientated routes. Being within the area defined as "the Pale" around Dublin and in parts of counties Kildare, Meath and Louth, Fingal was under predominantly English rule prior to and after 1600. This resulted in a relatively more organised system of responsibility for road development and maintenance here than in the rural parts of the rest of the country where irregular works to the natural or gravel roadways and structures would have been undertaken by local clans or septs.

The Parliamentary Acts of the early seventeenth century which sought to organise the systematic development and maintenance of roads and crossings, bolstered the successful system of road communication within the Pale and extended the range of good quality routes radiating from the Dublin area. The Cromwellian and Williamite upheavals of the later seventeenth century restricted the progress being made under the Acts but the following relative political stability and the huge increase in agricultural and industrial output towards the end of the century brought great advances in communications. This ultimately led to the major expansion of road networks throughout the eighteenth century, improvement of those routes already in well-serviced regions such as Fingal as vehicular traffic demanded better maintained surfaces and later, the development of the canals in the study area and elsewhere.

Turnpikes, in operation in Ireland from the early eighteenth century (and in the form of a tolled road north from Dublin from 1663 (Broderick 1996 p.15)) levied charges on the users of routes for the upkeep of the road surface and structures. *Figure 1* above outlines the extent of turnpike roads in the study area and although their exact routes varied over time, becoming more direct and capable of carrying greater traffic capacity, several routes within the Fingal area clearly owe a great deal of their development to this period of the toll-roads. The Dublin-Dunleer Turnpike originally passing over Gormanstown Bridge is the principal example in the study area but a turnpike also extended as far north as Knocksedan Bridge where tolls were used to fund developments on the road and bridges leading to this. Turnpikes in this part of Dublin were initially well serviced through the necessity to carry commercial traffic to and from the city but the economic depression following the Nepoleonic Wars in the early nineteenth century, the subsequent deterioration public finances leading up to the disastrous Great Famine and competition from the opening of the Dublin to Drogheda rail line in 1844 as well as from the heavy concentration of turnpikes north and west of Dublin (Andrews 1964) all contributed to the massive debt of the trusts in charge of toll roads in Fingal and the dissolution of these in the mid nineteenth century with management of the roadways reverting to the county grand juries. Following the advances of the early period of tolling on these routes, reduction through competition and economic problems in the toll receipts lead consequently to deterioration in condition of the road and bridges until their management was reorganised. Broderick (ibid. p.26) remarks on the willingness of the central government of the nineteenth century to invest huge sums in development of canal networks instead of and at the expense of maintaining the road systems and compares this with the approach of the French government who recognised the importance of arterial road networks and funded their upkeep accordingly from the eighteenth century.

The transport of linen from its production centre in the north eastern counties to the chief export centre of Dublin contributed a large volume of the traffic volumes using the turnpikes and alternative north-south routes through the Fingal area on which many of the road-bridges of this study are situated. This transport of linen increased up to the early eighteenth century but while production and export continued to steadily increase, traffic on the roads leading south to Dublin remained steady as a new linen hall was opened in Belfast in 1785 with export of the material and fibres from here to London and beyond. Also, from the late eighteenth to early nineteenth century, Drogheda emerged as a major export point for coarse semi-bleached linen and this contributed further to volumes of traffic on the north-south roads in the area. The expansion of cotton and fishing industries and the increased importation of coal in Balbriggan eventually drew the turnpike road towards the town which became a post town, with the road being diverted from Gormanstown Bridge to run across the new Delvin River crossing at Knocknagin in the early 1770s (see *figure 6*). Corn bounties paid on grain transported from the whole country for export through Dublin contributed a large proportion of the traffic on routes leading to the capital from the mid to late eighteenth century and these also applied to produce transported via the canals including the Royal Canal. From 1784 until they were abolished in 1797 however, the bounties applied to all Irish ports as Dublin was considered adequately supplied with bread so as not to warrant continued preferential treatment and dispute about the dispersal of bounties for upkeep of turnpike roads were developing.



Map 3 Showing portions of road diverted in eighteenth and nineteenth centuries. Based on the Ordnance Survey by permission of the Government. Permit No. 6169.

Figure 6. Re-routing of main Dublin-Dunleer turnpike with diversion from Gormanstown Bridge (circled red) to Knocknagin Bridge a short distance to the east (after Broderick 1996).

4. Masonry bridges: building conservation and structural issues

Most of our old stone bridges were built using lime mortar. Mud as a mortar and as a puddle over arch barrels is also to be found too. There are even a few dry stone bridges. These bridges have served us well not only because masonry is one of the most successful means of creating a robust structural span but also because of the mortar that was used. Lime mortar as in all masonry structures has two great advantages. The first is that it allows movement to take place within the joints without the cracking of the stones. The movement in a bridge is caused by both thermal expansion and contraction and live loading created by traffic. The second is that lime mortar creates a permeable structure that allows the water which inevitably gets in to get back out again. A typical bridge can be divided into the following elements:

- foundations
- abutments
- piers and cutwaters
- wing walls
- arch barrels
- spandrel walls
- spandrel fill (fill over arch barrel)
- parapets
- surfacing

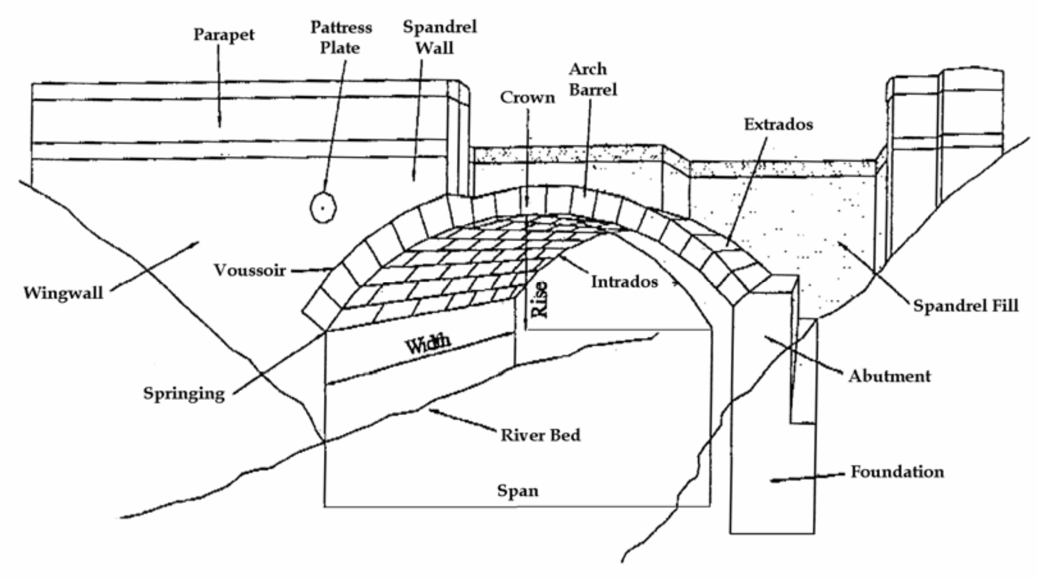


Figure 7: Bridge elements (after McAfee)

Each bridge and each of these elements needs to be examined in terms of what repair, if any is required. A particular lime mortar suitable for the repair of one element may not be appropriate for the repair of another.

Water is the prime deterioration agent of all stone structures. A bridge has not only water running at its base, but also water from above, and splashing from passing traffic. It is commonplace to see the effects of water from above when it washes out the original lime mortar from the bridge structure through the arch soffit and in particular, it tends to wash fines from the spandrel fill. The scouring action of water flowing at the base of the bridge can undermine piers and abutments and remove mortar from between the stones forming the arch barrel.

Part of the problem with many stone bridges constructed before the late nineteenth and early twentieth century zenith of masonry and mortar expertise, is that the masons often did not fully understand the properties of materials necessary for different elements of the structure. Lime mortars used in areas of the bridge likely to be kept permanently submerged in water should have had hydraulic or pozzolanic properties which can set in the absence of air but this was not always the case. Unfortunately even below the water line non-hydraulic lime seems to have been used at times in the past. To prevent the wash out of lime mortars in arch barrels, a cover of well-tempered puddle (clay) was considered desirable over the top of the barrel but this was not undertaken in all cases due either to lack of understanding or financial and time constraints.

Some faults are not accountable to the mortars that were used but are more basic masonry construction defects. Insufficiently bonded arch rings can often be observed in older bridges where the voussoirs did not extend far enough or were not tied correctly into the structure and a running crack developed as the entire arch collar detached from the rest of the barrel. Cutwaters were also often added after original construction of a bridge and were not tied adequately into the piers they abutted, with the result that they later became detached from the main structure. Other examples exist of cutwaters tied into the original constructed piers, but as a result of settlement from over-loading of the bridge or insufficient foundations, the ties have become cracked or broken separating the unloaded cutwater. Cracks in wing walls may have occurred from settlement due to building on unconsolidated fill or overly shallow foundations.

Missing voussoirs from the underside of arch barrels can be attributable to a loss of mortar but also to the consequence of the way some of these stones were laid in the original construction.

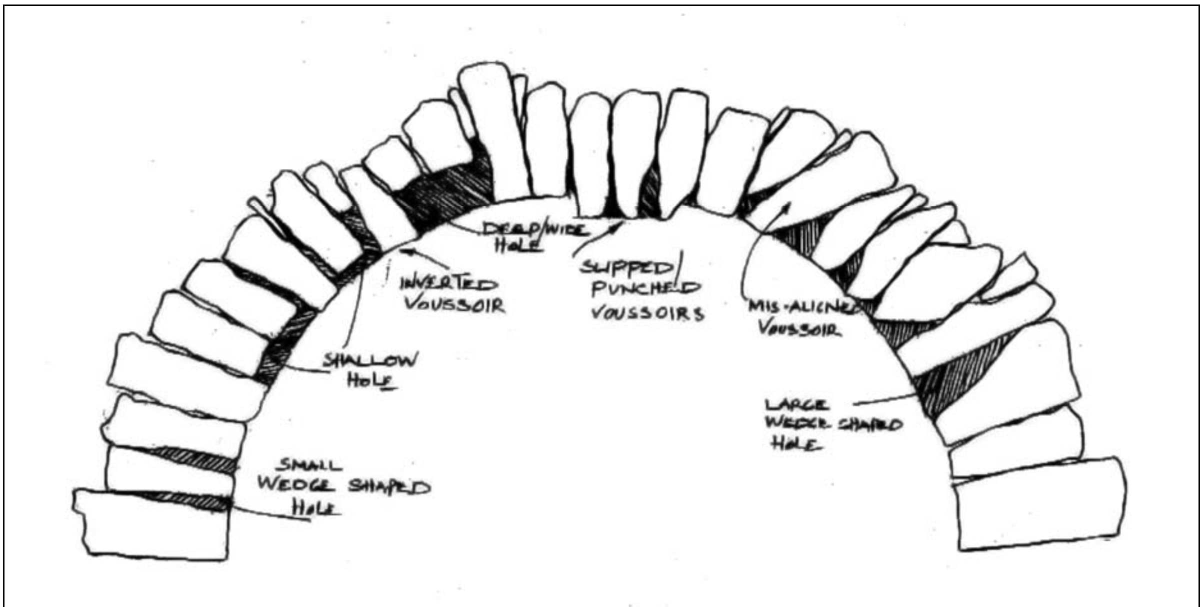


Figure 8: Intrados defects. (Illustration: Patrick McAfee).

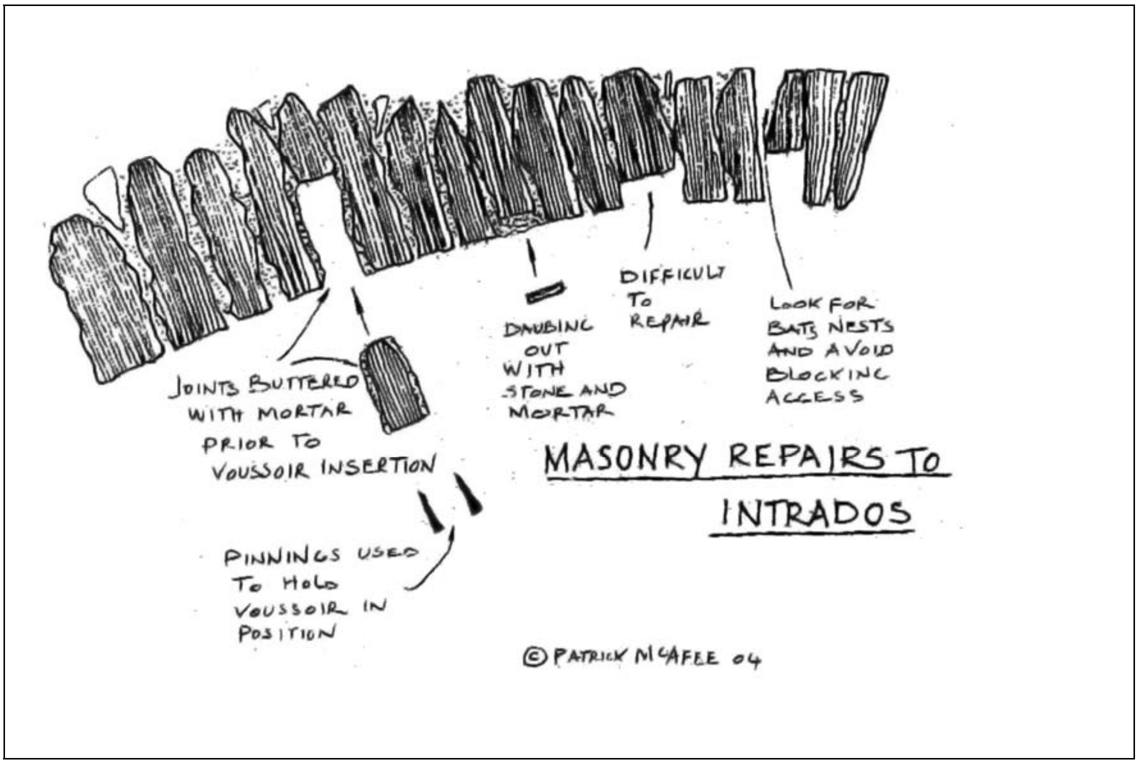


Figure 9: Masonry repairs to bridge intrados (Patrick McAfee)

Repairs below the water line will require a lime mortar with a greater hydraulicity than above the water line. A similar approach could be necessary on the inside of parapets which may suffer from the water splash of passing traffic and to the tops of parapets (without copings) which are subject to falling rain.

A lack of positive drainage (kerbs, gullies, longitudinal and transverse falls) can lead to vegetation growth in verges, wash-out of fines from the spandrel fill and lime mortar from the arch barrel. Improvement of drainage on bridges will help to reduce these effects.

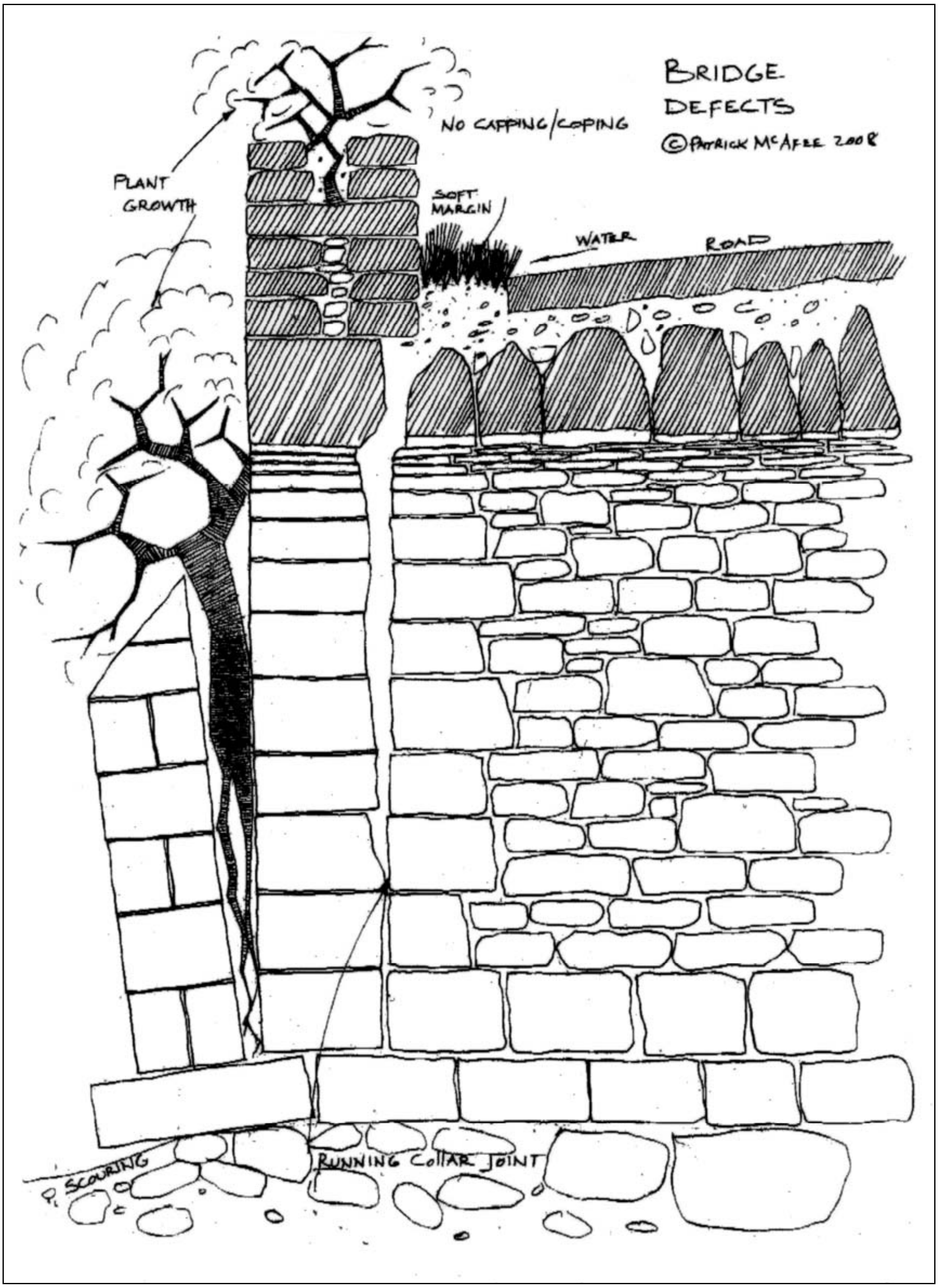


Figure 10: Bridge Defects (illustration by Patrick McAfee)

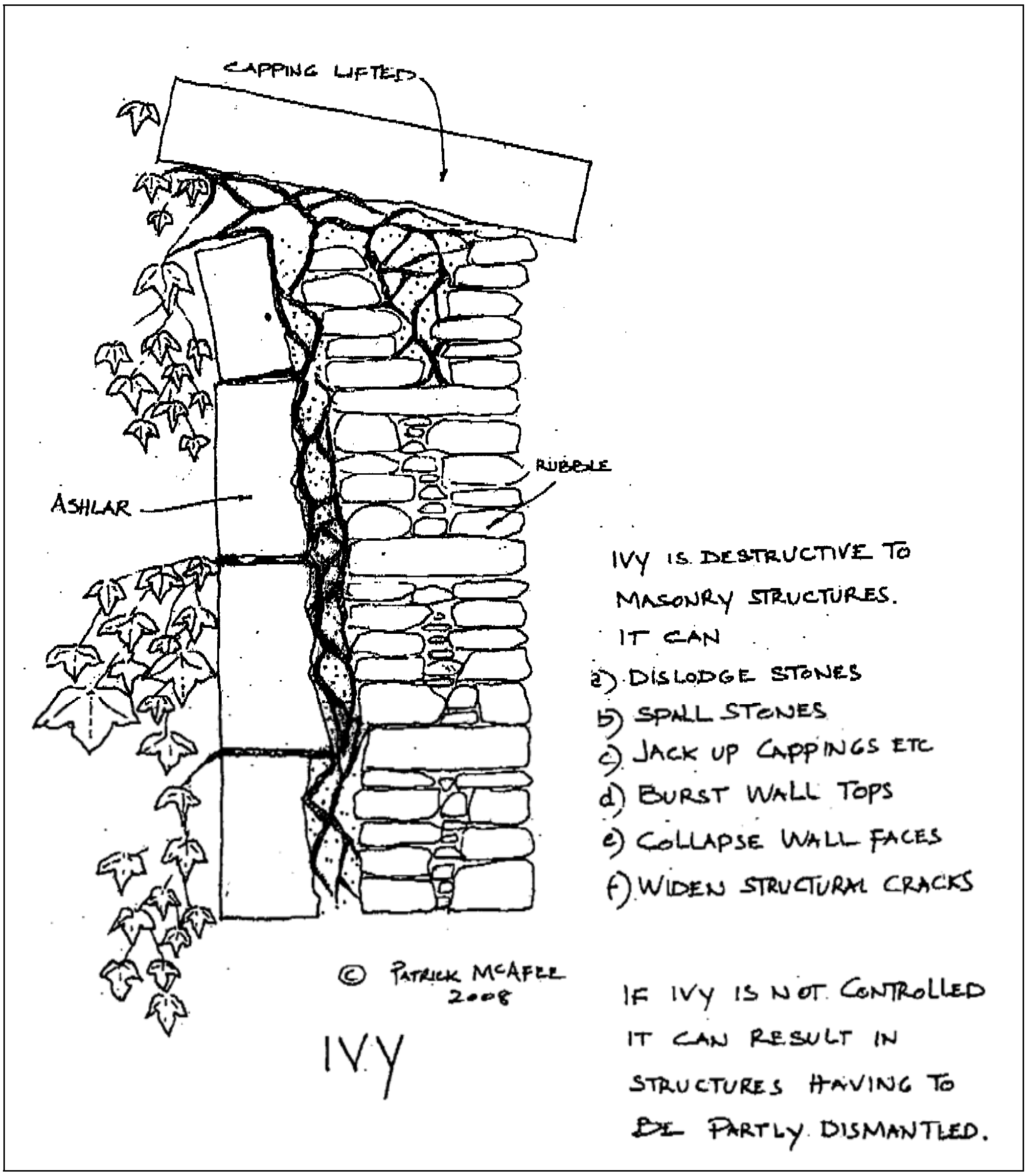


Figure 11: Negative impact of ivy growth on masonry structures (Patrick McAfee)

Vegetative growths such as ivy within washed-out joints and voids in the bridge can have a detrimental impact on the fabric and integrity of the structures as their roots exert pressure on masonry units and contribute to the weathering and fragmenting of lime mortar. Adequate bridge drainage and maintenance of pointing to masonry joints will reduce the potential for ivy and other deep-rooting vegetation to establish itself on the structure.

Pointing by itself is not always adequate to address the rooting of vegetation on masonry bridges as grouting of the spandrel fill may also be necessary. This technique can be employed if needed to address mortar loss due either to weathering since construction or simply poor placement and bedding of the original fill. Deformation of the road surface and potholes are often the most obvious indicators of settlement of spandrel fill.

It is often difficult to assess what voids may exist in spandrel fill prior to grouting works and, when a grout is used if it actually fills these voids as intended. The expert advice of an engineer experienced in traditional bridge repair should be sought on this issue and on bridge repair generally.

Partial re-build of spandrels, piers and abutments may be necessary if there is serious loss of original mortars and stones in these elements.

For isolated holes below the water line that need to be repaired quickly, a fast setting natural cement may be considered but it is generally best to restrict the use of natural cement to the minimum.

Bridges provide a habitat for many protected species, particularly bats, birds, fish, otters and insects. A favoured habitat for bats is under bridges. They are a protected species and professional advice and permission must be sought before commencing any work on a bridge. If bats are found, the work can take place during unrestricted periods to avoid disturbance during breeding or hibernation.

Lime too will kill fish if it gets in water in any quantity. Mortar droppings from hand pointing and from rebound which may result from mechanical pointing must be prevented from entering the watercourse. Boarded scaffolding with plastic sheeting is usually a sufficient precaution in most cases.

The National Roads Authority Bridge Management Group (Republic of Ireland) have experimented, tested and run trials on using lime mortars to repair bridges and have produced a specification for undertaking repointing using lime mortar (McAfee, 2008, pers. comm). If contractors do not have direct experience of using lime mortar then they should receive training in this type of work before being considered.

Structural assessments
Following the initial field inspection, two preliminary structural assessments were undertaken with a view to recommending good practice on how to conserve these bridges. The structures selected for inspection were Callaghan Bridge, Clonsilla (FHBS14) and Chapelmidway Bridge, to the west of Swords (FHBS12). It was considered that these bridges were the most representative of the fifteen bridges in the project sample and the assessments, which took place on December 3rd 2008 sought to confirm the defects noted by previous Dublin and Fingal County Council engineer inspections.

Chapelmidway Bridge
Chapelmidway Bridge is a three span arch structure, carrying a regional road over the River Ward. The original stone bridge has been extended twice in the past and now has a brick arch section and a reinforced concrete arch section. Each span measures 3.1m in width.

Plate 1: West upstream elevation of Chapelmidway Bridge (Photo Reference: FHBS-12-BH-01)

The bridge is in fair to good condition, but has a large bulge/sag in the arch ring on the Western side (original stone arch) in the southernmost span. There is some mortar loss in the stone arch section. The parapets do not conform with current standards. BD 52/07 is the current standard for parapets on national roads (there are no standards covering non-national roads), which states that masonry vehicle parapets shall not be used on bridges over, under or adjacent to national roads. However, if assessed using the Guidance Note for the Assessment and Design of Unreinforced Masonry Vehicular Parapets (County Surveyors Society, UK), it is likely that the parapets have adequate strength. The extensions to the original bridge are in good condition, but there is evidence of water leakage through the arch barrel.

Recommendation for repairs
Chapelmidway bridge is in reasonable to good condition and has a good carrying capacity (38T). However the sag in the arch barrel would give cause for concern. On masonry bridges with deformed arch rings it would be recommended that in the short term, the bridge is monitored on a regular basis (3 monthly) to ensure that movement is not ongoing. In the medium term, the deformed arch barrel should be reconstructed (over approximately 1/3 of the total width of the

bridge). To ensure stability of the arch during the construction works, the arch barrel should be replaced in narrow sections, say 4 number. To ensure that the heritage of the bridge is maintained, the same stone materials could be reused in the reconstruction. The works would need to undertaken from above and below to ensure that the new barrel was adequately supported during the works. This would necessitate a lane closure on the road, but the road is quite minor and it is anticipated that a lane closure would not result in long delays to the traffic.

At the same time, the bridge should be waterproofed to prevent further leakage through the stonework and re-pointed using lime mortar. The waterproofing should be undertaken to the extrados of the arch by excavating the fill around the arch, ensuring a smooth surface and by applying a waterproofing membrane. This would help to maintain the condition of the bridge into the future. The parapets should be assessed to prove adequacy of resistance to collision. If resistance was proved to be inadequate, safety barriers should be provided.

Callaghan Bridge
Callaghan Bridge is an elliptical profiled stone arch bridge, carrying the R121 road over the Royal Canal. The bridge is situated on a tight bend and is severely hump-backed. The span is 7.1m and there is a large clearance under the bridge to facilitate navigation of the canal beneath.

Plate 2: East elevation of Callaghan Bridge (Photo Reference: FHBS-14-BH-02)

The bridge is in good condition although there is mortar loss from the intrados in some areas. The substandard parapets have received collision damage in the past and have been repaired on more than one occasion with concrete blocks, which are not considered in keeping with the heritage of the bridge. As with Chapelmidway Bridge, the parapets do not conform with current standards (BD 52/07).

Recommendation for repairs
Callaghan Bridge is in good condition, but due to its shape and size it has a low capacity to take heavy vehicles (16.5t). It has mortar loss in areas of the intrados and the parapets have been damaged

by vehicular collision in the past. The mortar should be replaced where it has been lost with lime mortar.

The main problem with Callaghan Bridge is its proximity to the railway, its narrowness and the horizontal and vertical geometry of the road above it. It is highly constrained and was not designed for Heavy Goods Vehicles. There are three possible solutions to ensuring the bridge structure integrity is maintained/strengthened. The first option is the placement of a weight restriction on the bridge, which would deter large HGV's from using the bridge. This might also alleviate the possibility for collision damage. The second option is to widen the bridge (subject to topography and other constraints), which would alleviate future collision damage. The third option would be the implementation of single way traffic, limiting the traffic to the centre of the bridge only. Safety barriers could be installed inside the parapets to prevent collision damage. This option would have significant impacts on the traffic in the area. The preferred option would depend on the policy and budget of Fingal County Council and could be arrived at following a full feasibility study.

The carrying capacity of the bridge could be enhanced by the provision of a concrete saddle. The new saddle would sit on top of the existing arch and would be waterproofed. The waterproofing would help to prevent future mortar loss in the arch barrel. This solution may be limited by the already severe hump-back over the arch and the proximity of the railway lines. There are other strengthening solutions which incorporate the installation of reinforcing bars at strategic places around the arch, which could be combined with waterproofing of the existing arch barrel. Again, the preferred option would depend on the policy and budget of Fingal County Council and could be arrived at following a full feasibility study.

Statutory Protection

Under the Local Government (Planning and Development) Act, 2000, all Planning Authorities are obliged to keep a 'Record of Protected Structures' of special architectural, historical, archaeological, artistic, cultural, scientific, social or technical interest. As of the 1st January 2000, all structures listed for protection in current Development Plans, have become 'protected structures'. Since the introduction of this legislation, planning permission is required for any works to a protected structure that would affect its character. If a protected structure is endangered, planning authorities may issue a notice to the owner or occupier requiring works to be carried out. The Act contains comprehensive powers for local authorities to require the owners and occupiers to do works on a protected structure if it is endangered, or a protected structure or a townscape of special character that ought to be restored.

The protection applies to all parts of the structure that contribute to its character and special interest, including its interior, surrounding land or 'curtilage', any other structures on that land, their interiors, and all fixtures and features of these structures. It is important to note that protected structure status does not exclude development or alteration and maintenance or repair in accordance with conservation guidelines from the Department of Environment, Heritage and Local Government (DoEHLG). However, it does require the owner or occupier to consult with the planning authority, either through pre-application discussions, the planning application process, or through a declaration, to ensure that elements that make the structure significant are not lost during development or repair.

Also administered by local authorities are Architectural Conservation Areas (ACAs) which are delimited in an effort to preserve the "special character of an area". The ACA is based on the collective value of a group of structures which might not merit protected status in their own right.

The special character of the area includes "its traditional building stock and material finishes, spaces, streetscape, landscape and setting". It should again be pointed out that the designation of ACA status does not preclude development but aims to control it. It is important that new buildings within an ACA should respect the scale, massing and detailing of the existing building stock.

The NIAH is a survey of sites of architectural significance which was devised to assist in evaluating structures to be included in the RPS. Listing on the NIAH does not necessarily carry any statutory responsibilities to the owner to protect the site but it does highlight the culturally significant aspects of the structure which ought to be conserved.

Section 12 (1) of the National Monuments (Amendment) Act, 1994 made provision for the establishment and maintenance of a Record of Monuments and Places (RMP) deemed to have cultural heritage potential. Superseding the Register of Historic Monuments, which was established under the 1987 Amendment to the Act, the RMP comprises of a list and maps of monuments and relevant places in respect of each county in the State. All sites recorded on the RMP receive statutory protection under the National Monuments Act 1994 and any work undertaken at these sites must be done so under licence (Section 12 (3)) from the DoEHLG. Sites classified as having National Monument status must receive ministerial consent for any changes or works to the site while the minister must be notified prior to any works taking place to a site on the RMP.

5. *Ecology and bridges*

Many historic bridges have become colonised over time by plants and animals, becoming valuable habitats in the local area. In addition, bridges function together with other habitat elements in the wider landscape, influencing the movement, feeding and sheltering behaviours of wildlife. Therefore, bridge repair and maintenance works have the potential to negatively impact on habitats and species of conservation interest, some of which are afforded legal protection. Thus it is important that bridge works are conducted in a way that safeguards their natural heritage value. This section provides an overview of the habitats, flora and fauna of bridges in Ireland and in Fingal in particular, providing a context for the natural heritage recommendations for individual bridges in the following section.

Scientific names of species named in text are provided in the appendix below.

Habitats

Habitats in Ireland are classified according to habitat descriptions and codes published in the Heritage Council's A Guide to Habitats in Ireland (Fossitt, 2000), Older stone bridges and associated stonework are best classified as stone walls and other stonework (BL1). Newer, more intact stone bridges and bridges of other material, such as concrete or steel, are best classified as buildings and artificial surfaces (BL3). As a general rule, older stone bridges with loose or crumbling mortar are of higher value as plant habitats than newer stone bridges, such as those from the Victorian era, or bridges of concrete or steel. Several factors relating to the age and construction of stone bridges influence a bridge's natural heritage value. These can include the type of stone (especially whether the stone is acidic or basic), composition and integrity of mortar, nature of joints, age and the degree of maintenance.

In addition to the habitat value of bridges themselves bridges are associated with other habitat types, including the watercourses crossed by bridges. Bridges in the Fingal area generally span three types of watercourse: lowland rivers (FW2), canals (FW3) and tidal rivers (CW2) (habitat codes as per Fossitt (2000)). Terrestrial habitats near bridges in Fingal include but are not limited to hedgerows (WL1), treelines (WL2), improved grasslands (GA), arable agriculture (BC), woodlands (WD & WN), buildings and artificial surfaces (BL3) and saltmarshes (CM). These and other habitats may be used by plants and animals of conservation interest or may be part of areas designated for nature conservation, as discussed below.

Riparian fringe habitats, such as hedgerows (WL1) and treelines (WL2) adjacent to watercourses, have an important role in maintaining ecological connectivity in the vicinity of bridges. The riparian fringe allows wildlife, including plants, to move through the landscape to find suitable habitats for feeding, breeding and other activities (*Figure 12*). In an area which is largely defined by human activity, such as intensive agriculture or urban areas, riparian fringe vegetation is particularly important. Additionally, a network of hedgerows and treelines along field boundaries connecting to riparian zones and bridges can provide viable transport routes throughout the immediate landscape. These wildlife corridors are particularly valuable for species resident in bridges, such as bats. In some cases, trees and shrubs associated with riparian vegetation can damage bridge structures, mainly in the form of tree roots and limbs disrupting the bridge's structural integrity. However, given the ecological value of hedgerows and treelines in the vicinity of bridges, it is important that maintenance works on bridges preserves these wildlife corridors.

Of the 15 bridges surveyed in this study, two of the three bridges situated over the Royal Canal (FHBS-13, FHBS-14) were associated with good wildlife corridors in the form of treelines composed of Alder, Ash and Sycamore on either side of the canal. Many of the bridges situated within rural areas (bridges FHBS-01, FHBS-04 and FHBS-09) also exhibited good connectivity due to the presence of hedgerows and treelines upstream and downstream of the bridges, in addition to adjacent field habitats. Conversely some bridges within the rural areas (bridges FHBS-03, FHBS-08 and FHBS-10) exhibited poor connectivity due to lack of adjoining hedgerows and the replacement of hedgerows on field boundaries with fencing.

Figure 12: Ecological connectivity of bridges and the local landscape

In addition to its wildlife corridor value, riparian vegetation has many benefits for aquatic fauna including shading, which regulates water temperature, bank stability, provision of bankside microhabitats and food inputs in the form of fallen leaves, stems, etc.

Riparian vegetation within the immediate vicinity of the bridges must be retained where possible, and bridge works must take account of opportunities for integrating the bridge habitats, flora and fauna with habitats and land use in the wider landscape. Riparian zone vegetation provides valuable ecological connectivity, feeding and nesting/roosting opportunities in landscapes dominated by intensive agricultural practices and human activity. It provides important functions in regulating watercourse temperature and other functions. Riparian vegetation provides a viable buffering function by trapping and retaining run-off from nearby habitats which contributes to an overall increase in water quality. In the event of riparian zone removal the resultant soil and bare ground habitats need to be stabilised with suitable mitigation measures taken against any sediment mobilisation into the watercourse. Silt fencing and silt traps should be erected to collect any mobilised suspended material.

Where riparian vegetation is currently absent or patchy, there is an opportunity to enhance ecological connectivity and conservation value in the vicinity of bridges by planting trees and shrubs. Planted species should be native to Fingal and characteristic of Fingal watercourses. Suitable tree species include Alder, Downy Birch and Rusty Sally, and suitable shrubs include Hazel, Hawthorn, Blackthorn and Holly. Where they are characteristic of a particular stretch of watercourse, long-naturalised willow species such as Crack Willow, White Willow, Osier and Purple Osier may be suitable. Advice on species and planting should be sought from an ecologist or similar professional with expertise in native habitat restoration.

Designated areas

Special Areas of Conservation (SACs) and Special Protection Areas for birds (SPAs) are sites that are deemed to be of European (i.e. international) importance for natural heritage conservation. They form part of a network of sites designated across Europe in order to protect biodiversity within the community, known as Natura 2000 sites. SACs are designated under the EU Habitats Directive (92/43/EEC), as transcribed into Irish law by the European Communities (Natural Habitats) Regulations, 1997 (and amendments). Candidate SACs (cSACs) are sites whose designation not yet been finalised, but are still afforded full protection under the Habitats Directive. SPAs are designated under the EU Birds Directive (79/4089/EEC), as transposed into Irish law by the European Communities (Conservation of Wild Birds) Regulations, 1985 (and amendments).

Natural Heritage Areas (NHAs) are designated under Irish law to protect habitats, flora, fauna and geological sites of national importance. The legislative framework for NHAs is provided by the Wildlife Act, 1976 and the Wildlife (Amendment) Act, 2000. Proposed NHAs (pNHAs) are sites that have not yet received formal designation and do not yet have statutory protection. However, the conservation value of pNHAs is recognised by national and local authorities, and policies to protect pNHAs are included in the planning process, including the Fingal Development Plan 2005-2011.

All the watercourses over which the bridges in the study cross eventually flow into estuaries that are subject to a number of conservation designations. In addition, the Royal Canal is itself a pNHA. The approximate distances from each bridge to various designated areas downstream are indicated in *Table 2*. Bridge maintenance works that could impact designated areas must involve consultation with the National Parks and Wildlife Service (NPWS) to determine what legal consents are required, what works may be permitted and what mitigation measures may be required. This is discussed further in the recommendations section below.

Works within sites designated for nature conservation will require approval of the NPWS. In addition, works that have the potential to impact on designated areas downstream will also require NPWS approval. We recommend that works upstream of designated areas will require consultation with NPWS and the Fingal Biodiversity Officer to determine the requirements for consents, assessments and mitigation. Designated areas include NHAs, SACs and SPAs. Of the bridges in this study, the NPWS will need to be consulted prior to any works on the three bridges situated over the Royal Canal pNHA (FHBS-13, FHBS-14 and FHBS-15) and on Ballymadrough Bridge (FHBS-10), which is situated less than 100m upstream of the Malahide Estuary pNHA/ cSAC and the Broadmeadow/Swords Estuary SPA. Where there is a potential for negative impacts on the conservation objectives of Natura 2000 sites (SACs and SPAs), screening will be required to determine the need for an Appropriate Assessment under Article 6 of the EU Habitats Directive. According to Article 6(3) of the Habitats Directive, "any plan or project not directly connected with or necessary to the management of the site but likely to have a significant effect thereon either individually or in combination with other plans or projects, shall be subject to Appropriate

Assessment of its implications for the site in view of the site's conservation objectives" (European Commission, 2002).

Some bridges may be associated with habitats of conservation importance outside of designated areas. For example, FHBS-10 is situated adjacent to saltmarsh habitat outside of the Malahide Estuary cSAC. Saltmarsh habitats are listed in the Habitats Directive as habitats of European conservation importance. Similarly, bridges may be associated with floating river vegetation characterised by aquatic plant species rooted in the river substrate, including water crowfoots, water milfoils and pondweeds, although this habitat type was not found in the vicinity of any of the 15 bridges in this survey. This floating river vegetation habitat is also listed in the Habitats Directive as habitats of European conservation importance.

Table 2 – Designated Areas.

Bridge & Reference Number	Distance upstream of designated areas	Designated area(s)
Gormanstown Bridge *FHBS01*	1.2 km	River Nanny and Estuary Shore SPA (004158)
Old Mill Bridge *FHBS02*	5km	River Nanny and Estuary Shore SPA (004158)
Garristown Bridge *FHBS03*	14km	River Nanny and Estuary Shore SPA (004158)
Cockles Bridge *FHBS04*	12km	River Nanny and Estuary Shore SPA (004158)
Oldtown Bridge *FHBS05*	10.5km	Rogerstown Estuary pNHA/ cSAC (000208)
	13km	Rogerstown Estuary SPA (004015)
Ballyboghill Bridge *FHBS06*	6.5km	Rogerstown Estuary pNHA/ cSAC (000208)
	9km	Rogerstown Estuary (004015)
Lispopple Bridge *FHBS07*	6km	Malahide Estuary pNHA/ cSAC (000205) and Broadmeadow/Swords Estuary SPA (004025)
Roganstown Bridge *FHBS08*	5km	Malahide Estuary pNHA/ cSAC (000205) and Broadmeadow/Swords Estuary SPA (004025)
Mack's Bridge *FHBS09*	1.5km	Malahide Estuary pNHA/ cSAC (000205) and Broadmeadow/Swords Estuary SPA (004025)
Ballymadrough Bridge *FHBS10*	<100m	Malahide Estuary pNHA/ cSAC (000205) and Broadmeadow /Swords Estuary SPA (004025)
Knocksedan Bridge *FHBS11*	5.5km	Malahide Estuary pNHA/ cSAC (000205) and Broadmeadow/Swords Estuary SPA (004025)
Chapelmidway Bridge	8.5km	Malahide Estuary pNHA/ cSAC (000205) and

Bridge & Reference Number	Distance upstream of designated areas	Designated area(s)
FHBS12		Broadmeadow/Swords Estuary SPA (004025)
Kirkpatrick Bridge *FHBS13*	on-site	Situated within Royal Canal pNHA (002103)
Callaghan Bridge *FHBS14*	on-site	Situated within Royal Canal pNHA (002103)
Collins Bridge *FHBS15*	on-site	Situated within Royal Canal pNHA (002103)

Flora

Old stone bridges can support a diverse flora comprised of lichens, algae, mosses, liverworts and ferns. They increase the biodiversity value of the local landscape and provide an important basis for plant colonisation on artificial surfaces. One of the most common native species often associated with stone walls and bridges is Ivy, which can form dense coverings. Dense growth of Ivy is of benefit to wildlife such as bats and birds, providing potential habitat for roosting and nesting and providing feeding opportunities in the form of berries and insects. This value is increased in areas where mature trees or scrub are uncommon. On the other hand, woody plants growing on or near bridges can be structurally damaging, as noted in Section 4 above. The challenge when undertaking maintenance work on bridges is that a balance must be struck between the conserving the natural heritage value of the bridge flora and associated fauna whilst controlling damage to the structural integrity and built heritage value of the bridge structure from woody vegetation, such as Ivy.

A summary of typical or common vascular plant species occurring on bridges in north County Dublin and an assessment of their potential for damaging bridge structures is presented in *Table 3* below, based on information from Doogue et al. (1998), Fossitt (2000) and field observations. This list is indicative only, as many other species can also occur on bridges but are not characteristic of the exposed stone of bridge parapets and walls. For example, a grassy roadside verge flora can often develop between the road surface and the bridge parapet. Common weed species, such as Dandelion and Sow-thistles can grow in the crevices of stone bridges, but they are not characteristic stone wall or bridge species.

Characteristic plant species of bridges in Ireland and in Fingal include the ferns Maidenhair spleenwort, Wall-rue (plate 3), Polypody species and Rusty-back. Hart's tongue and Male fern grow on bridges where the stone is damper, either due to localised seepage from the bridge structure or proximity to the watercourse. Frequently occurring flowering plant species include Hair-grasses, Stonecrops, Herb Robert, Navelwort, Pellitory-of-the-wall and Ivy-leaved toadflax.

These characteristic wall species are small, non-woody and pose little threat to the bridge fabric, and thus should be maintained on bridges wherever possible (*Table 3*). However, if removal of non-damaging species is necessary, this should only be done following consultation with the Fingal Biodiversity Officer. Practices such as spraying of entire bridge surfaces with herbicide are not permissible. Where extensive clearance of non-damaging species is necessary, a botanical survey should be conducted to ensure that no legally protected or rare species are affected.

Other species have larger roots and rhizomes that can damage the structural integrity of built surfaces contributing to their eventual breakdown if left unchecked over many years. These include Ivy, tree species, Wallflower, Butterfly bush and Red valerian (*Table 3*). The latter three are commonly recorded in urban areas growing out of city walls, quays and some bridges. Not only do these larger species potentially damage bridges, but in general they are more vigorous and can colonise large sections of bridge habitats thereby out-competing other species.

Overall plant species diversity from the fifteen bridges surveyed was not particularly high, as the nature of the mortar and joins in the bridges was generally not favourable to plant colonisation. FHBS-01, the oldest bridge in the survey, supported the highest density and abundance of typical bridge species, including Wall-rue, Common polypody, Pellitory-of-the-wall and Hart's tongue. These species occurred less frequently on other bridges in the survey in addition to Ivy leaved toadflax, Herb Robert and Broadleaved willowherb. Grass species were also recorded on some of the bridge structures, many of which grow within a wide range of habitats, including artificial or man made habitats. Species identified included Annual meadow grass, Red fescue, Yorkshire fog and Cocksfoot.

Table 3: Typical vascular plants of bridges and the level of threat posed to bridge structures.

Species / Species Group	Native Status	Potentially Damaging to Bridges?
Butterfly bush	non-native	yes
Ivy	native	yes
Red valerian	non-native	yes
Trees (e.g. Sycamore, Ash, Elder)	native & non-native	yes
Bramble	native	yes
Wallflower	non-native	yes
Annual meadow grass	native	no
Maidenhair spleenwort	native	no
Fern-grass	native	no
Hair-grasses	native	no
Hart's tongue	native	no
Herb Robert	native	no
Ivy-leaved toadflax	non-native	no
Navelwort	native	no
Pellitory-of-the-wall	non-native	no
Polypody ferns	native	no
Red fescue	native	no
Rusty-back fern	native	no
Shining cranesbill	native	no
Stonecrops	native & non-native	no
Thyme-leaved sandwort	native	no
Wall-rue	native	no

The most common species identified during the study was Ivy, which formed dense patches on bridge parapets, side walls and buttresses of bridges FHBS-01, FHBS-04, FHBS-05, FHBS-10, FHBS-11, FHBS-13 and FHBS-14. Immature trees and shrub species were also identified in the environs of several bridges. Many of these were associated with the immediate environs of the bridge structure rather than establishing upon the bridge itself. Those rooting on the bridge itself included young Ash, Hawthorn, Elder and Butterfly bush. Another shrub species included Bramble which was identified on many of the bridge structures often growing with Ivy.

Although no locally rare, nationally rare or legally protected plant species were found in or around bridges during this survey, some are known from or have the potential to occur in the vicinity of other bridges in Fingal. For example, Rue-leaved saxifrage is frequently associated with stone walls but is rare in Co. Dublin (though not in Ireland as a whole); it has been recorded on bridges in Fingal in the past (Doogue et al., 1998). There are few nationally rare or protected species associated with bridges in Co. Dublin. Opposite-leaved pondweed is protected under the Flora (Protection) Order, 1999 and is listed as Vulnerable in the Red Data Book (Curtis and McGough, 1988); it is known from the Royal Canal near Cross Guns and Binn's Bridges. Round-leaved cranesbill is a Vulnerable species (Curtis and McGough, 1988) that occurs on walls in Co. Cork, but has only been found on waste ground in Co. Dublin, where it was probably introduced (Doogue et al., 1998). Rare species characteristic of waste ground that occur in Co. Dublin have the potential to occur on the top of bridge parapets and walls.

Plate 3: Wall-rue, a characteristic fern of stone bridges that is not damaging to the bridge structure.

Invasive species

Plants growing along rivers in Fingal can also include invasive, non-native species, including Japanese Knotweed (*Plate 4*) and Giant Hogweed (*Plate 5*). The latter has toxic sap that can cause serious health problems to people that come into contact with it. This is a significant health and safety issue that requires appropriate safeguards to address the risk associated with working in the vicinity of Giant Hogweed. Giant Hogweed was not found near any of the bridges in this survey, but Japanese Knotweed and Montbretia occur downstream of Oldtown Bridge (FHBS-05) (*Plate 6*).

Promoting the spread of invasive, non-native species is an offence under the Wildlife (Amendment) Act, 2000, and thus bridge works in the vicinity of such plants must take care not to encourage them. In general, works should not take place near invasive species during fruiting so as to minimise risk of spreading seeds or fruits. Disturbing areas near invasive plants should be minimised. Vehicles and other equipment used in the vicinity of invasive plants must be washed prior to use at other sites. Soil from areas near invasive plants must not be translocated to other areas. Where possible, populations of invasive plant species should be eradicated. Further guidance on controlling invasive plant species is available through Invasive Species Ireland (www.invasivespeciesireland.com).

Plate 4: Japanese Knotweed, an invasive exotic species

Plate 5: Giant Hogweed, an invasive exotic species toxic to humans

Plate 6: Japanese Knotweed and Montbretia at Oldtown Bridge (FHBS-05)

Vegetation control

As noted above, small, non-woody plant species that pose little threat to the bridge fabric should be maintained on bridges where possible. Where vegetation control on or near bridges is necessary, mechanical means are preferable to chemical methods. Broadcast spraying of herbicide can negatively impact non-damaging flora as discussed above and can also have serious water quality impacts. Trees can be felled and Ivy can be severed at the base where it roots into the soil.

Where herbicide use is considered unavoidable, the Fisheries Board must be consulted prior to the use of herbicides on bridge structures. The type of herbicide used, in addition to the dilution/ volume of herbicide used, must be in compliance with the Fisheries Board best practice. Preferably herbicide application will be used in conjunction with mechanical control. This will involve the initial cutting of the plant stem before directly treating the remaining stump and root vegetation with herbicide. This will allow for a reduced herbicide use in addition to directly targeting the root of each plant. This method of treatment will minimise potential run-off into watercourses and will require less herbicide use overall.

According to Section 46 of the Wildlife (Amendment) Act, 2000, "1(a) It shall be an offence for a person to cut, grub, burn or otherwise destroy, during the period beginning on the 1st day of March and ending on the 31st day of August in any year, any vegetation growing on any land not then cultivated. (b) It shall be an offence for a person to cut, grub, burn or otherwise destroy any vegetation growing in any hedge or ditch during the period mentioned in paragraph (a) of this subsection." It is unclear whether this section applies to vegetation on bridges, and there are several exceptions to this prohibition which may or may not apply to bridge maintenance. Nevertheless, to protect nesting birds and mammal habitation, tree felling and Ivy or other vegetation clearance should not be performed from 1st March through 31st August, inclusive, unless surveys have been undertaken to ensure lack of occupation.

It is preferable that tree felling be carried out prior to the period of bat hibernation and subsequent to the breeding period and bird nesting period. This would indicate September and October as the best period within which to clear vegetation, following inspection by a bat specialist. Where bats are noted to be within a tree or Ivy prior to felling or clearance, NPWS consent for the works will be required in the form of a derogation license as discussed below.

Bats and bridges

All bat species are strictly protected under Irish and European law, as discussed below. In the past, bridges were largely overlooked as potential bat roosts, but recent studies have indicated that bats often roost within the crevices and small openings of bridges. Heavier loads of traffic put increased stress on the structural integrity of bridges and damage to abutments can occur during river spate or through water seepage. The mortar and grout between the block-work becomes eroded by these processes, leaving open cavities and fissures that can act as roost sites for bats. The small size of Irish bat species (*Plate 7*) means that they can occupy very small crevices in masonry. Bats have preference for crevice sizes of between 13mm-70mm in width to 350mm-1000mm in depth for summer roosts and deeper for winter hibernation sites (Billington & Norman, 1997).

Plate 7: Common Pipistrelle

Recent research highlights the value of bridges for bats and indicates the species most likely to be encountered and their patterns of bridge use. Smiddy (1991) found that 14% of bridges surveyed in east Cork and west Waterford contained roosting bats. A further 11% showed evidence of having been used recently, while another 26% were considered suitable for use. Species recorded included Whiskered bat, Natterer's bat, Daubenton's bat, Pipistrelle species and Brown long-eared bat. Many bridges appeared to be used irregularly or for short periods only and different species occasionally occupied the same bridge at different times within and between years. The report also concluded that Pipistrelles did not appear to favour bridges as a roosting site. Shiel (1999) recorded five bat species roosting within bridges in Leitrim and Sligo, including Daubenton's, Natterer's, Whiskered, Brown long-eared bats and Pipistrelles. Masterson et al. (2008) investigated bridge usage by bats in County Cork and found that highlighted that bridge structures are used by bats in high numbers where suitable crevices occur. In addition to crevices within the masonry of the bridge, dense Ivy cover can also provide suitable day roosting for some species of bats.

Gormanstown bridge (FHBS-01) and Knocksedan Bridge (FHBS-11) exhibited the greatest potential to support bat roosts based principally on suitable crevices within the bridge structure. In addition, many of the bridge structures surveyed supported dense Ivy growth on the bridge parapets and side walls, which also has potential to support bat species. These included bridges FHBS02, FHBS05, FHBS07, FHBS10, FHBS-11, FHBS-13 and FHBS-14. The potential for other bridges to support bat roosts is described in the bridge summaries in Volume 2.

Where bats are roosting within bridges, upgrading works can have a seriously negative effect. The closure of crevices and openings within bridge under-arches and parapet walls can result in the entombment of bats or the prevention of access to roosting cavities, which may result in the abandonment of young bats. Bridge crevices can also be sealed through natural processes either by the roots of vegetation growing upon the bridge or in bridges composed of limestone substrates where continual leaching from limestone rocks creates a build up of a calcareous leachate in existing crevices (NRA, 2005). Stripping Ivy from bridges can also harm any bats that may be roosting within the vegetation cover.

Habitat fragmentation is also a major concern to bats in bridges as they rely on commuting routes through the landscape to link their varied seasonal habitat requirements (*Figure*). Tree-lines and mature well-managed hedgerows function as wildlife corridors, which provide cover and shelter between roost sites and foraging sites. A break in a hedge line for 10m or more can cut bats off from a foraging site. There are also implications for breeding bats with hedgerow loss, because Leisler's bats have been shown to use hedgerow trees as advertising posts during mating and the loss of these may have an effect on their ability to find a mate and to reproduce (EHS and NPWS, 2008). Pools downstream of bridges sheltered by riparian hedgerows or tree-lines provide ideal feeding habitat for Daubenton's bats (*Figure*). Bridges FHBS-01, FHBS-02, FHBS-04, FHBS-09 and FHBS-11, FHBS-13 and FHBS-15 exhibited suitable riparian habitats, principally hedgerows and tree-lines, within the immediate vicinity of the bridge. These habitats would facilitate the movement of bats to and from bridge structures in addition to provide viable foraging areas.

Other threats include works associated with development or building, which are likely to lead to an increase in human presence at the site, extra noise and changes in the site layout and local environment. Light pollution is another potentially significant factor, particularly where a previously unlit bridge is provided with artificial lighting. All these may have a detrimental effect on the bats, which seek particular environmental conditions, such as a low incidence of direct human disturbance, particular temperature and humidity regimes and a stable internal and external layout so they can continue to follow established flight-paths (Kelleher and Marnell, 2006). Lighting that impacts on the sides of bridges or on the watercourse below can result in the abandonment of roosts.

The impact of the loss of roosts on bat populations is believed to be an important factor in the decline of bat populations generally. For some species which are known to move between roosts, and which rely less heavily on sites with special characteristics, the loss of a single maternity or hibernation roost may be less critical than for more specialised species. Hibernation sites used by significant numbers of bats may be a critical resource for the local bat population, particularly in times of cold weather, and may be used by bats from a wide area (Kelleher and Marnell 2006).

Protecting bats

All bats are protected in Ireland under the Wildlife Act, 1976 and the Wildlife (Amendment) Act, 2000. All species of bats are strictly protected under Annex IV of the EU Habitats Directive (92/43/EEC) as transposed into Irish law in the Habitats Regulations, 1997. (Lesser horseshoe bat is also strictly protected under Annex II of the EU Habitats Directive, but does not occur in County Dublin.) In addition, all Irish bats are protected by the Bonn Convention (1992) (Agreement on the Conservation of Bats) and the Berne Convention (1982). Pipistrelles are on Appendix III of the Berne Convention (protected).

According to Regulation 23 of the Habitats Regulations 1997, any person who in regard to bats or other species listed in Annex IV of the Habitats Directive:

> *"(a) deliberately captures or kills any specimen of these species in the wild,*
>
> *(b) deliberately disturbs these species particularly during the period of breeding, rearing, hibernation and migration,*
>
> *(c) deliberately takes or destroys the eggs from the wild, or*
>
> *(d) damages or destroys a breeding site or resting place of such an animal,*
>
> *shall be guilty of an offence."*

According to the circular from NPWS of 16th May, 2007 (2/07), "it should be noted that in the case of Regulation 23 (d), it is not necessary that the action should be deliberate for an offence to occur. This places an onus of due diligence on anyone proposing to carry out an action or project that might result in such damage or destruction." Furthermore, the circular states that "examples of cases that are likely to require assessment are the removal of trees and other habitat… and even the re-pointing or replacement of masonry in bridges…"

To comply with the above regulations during bridge maintenance works, the following process must be followed:

1) an assessment by a bat specialist for bridges with the potential to support bats,

2) application to NPWS for a derogation license if necessary and

3) required mitigation as appropriate.

As this process may be lengthy, there is the potential for delays to any bridge maintenance programme. Therefore, it is important that bridges with the potential to support roosting bats are assessed by a bat specialist early in the design stage.

Prior to undertaking any maintenance or restructuring works on bridges with potential to support roosting bats, a bat survey of each bridge must be undertaken by a bat specialist. Due to the potential for bat roosting in trees and Ivy, a bat specialist must also be consulted prior to clearance of dense Ivy growth and felling of trees adjacent to bridges. Consultation with the Fingal Biodiversity Officer and NPWS should be undertaken to evaluate bat potential for bridges not assessed in this study.

If the bridge is used by bats and the proposed works present a risk of damage or disturbance to bats, a derogation license to carry out works will be required from NPWS. Any application for a derogation license "should be made in advance of seeking approval under Part 8 or 10 of the Planning and Development Regulations, 2001, as amended, or seeking planning permission for works" (NPWS 2/07). The application for the derogation license must include appropriate mitigation measures to address potential impacts on bats.

Mitigation for a bridge occupied by bats may include exclusion by a bat specialist. Other measures can include the incorporation of bat boxes or bat tubes in the bridge fabric. Provision of lighting at bridges must ensure that no light reaches watercourses to reduce impacts on bats and other species, including Otter. Similarly, lights must not be directed at the sides of bridges to permit the establishment or maintenance of bat roosts. Where lighting is necessary, directional lighting and full cut-off lighting (where no light is permitted to escape above the horizontal level of the lamp) should be employed.

It is preferable that tree felling be carried out prior to the period of bat hibernation and subsequent to the breeding period and bird nesting period. This would indicate September and October as the best period within which to clear vegetation, following inspection by a bat specialist. Where bats are noted to be within a tree or Ivy prior to felling or clearance, it will be necessary to postpone felling to create the opportunity for bats to cease usage. If bats do not leave a tree or bridge within a reasonable time, it may be possible for a bat specialist to exclude the bats or otherwise remove them. This must be carried out by a qualified bat specialist with a derogation license from NPWS as discussed above.

Additional guidance on bat mitigation is provided by Kelleher and Marnell (2006). In general, works to be undertaken on bridges should follow the NRA's Best Practice Guidelines for the Conservation of Bats (2005) and Guidelines for the Treatment of Bats (2006).

Otter and other mammals

Otters are semi-aquatic carnivores that are widespread throughout all Irish freshwater and coastal habitats (NPWS, 2008a). Otters are strictly protected under Annexes II and IV of the EU Habitats Directive. They are also listed on the Irish Red Data book as a Vulnerable species (Whilde, 1993), and they are protected under the Wildlife Acts of 1976 and 2000. Otters typically have resting places within their territories called couches when situated above ground or holts when located underground. Holts are most commonly found among trees roots, although bramble scrub is also used (NPWS, 2008). Each adult otter has its own home range, which it marks with its faeces (spraints) at prominent locations such as instream rocks often situated nearby bridges. When groups of otters are evident, they usually consist of a female and her young. Range sizes vary widely according to the quality of the foraging habitat and other resources, such as suitable sites for otter holts (NRA, 2007).

Otter activity was confirmed in the field at only one of the bridge sites. This occurred at FHBS-4 (Cockles Bridge) where an otter spraint was identified on an instream rock immediately upstream of the bridge structure. The spraint also contained crayfish remains, a species of conservation concern listed on Annex II of the EU Habitats Directive.

Consultation with the local NPWS ranger clarified that otter activity is known from the Broadmeadow River, within the vicinities of bridges FHBS-7 and FHBS-8, and the Ward River, within the vicinities of bridges FHBS-12 and FHBS-13.

Bridges have the potential to form an obstruction to the movement of otters up and downstream. As otters travel both via land and by water, it is important that a bridge permits the passage of otters along a stream by both of these routes. Otter passage under bridges via water is generally not an issue, but many bridges do not permit dry-land passage, particularly during flood conditions. The National Roads Authority (NRA) requires that all new crossings of watercourses used by otters provide a dry-land path, ledge or similar adjacent to the stream, in addition to maintaining free passage via water (NRA, 2007).

Vegetation clearance and structural works in the environs of bridges must also avoid the disturbance and/or destruction of otter holts. Otters are strictly protected under the Habitats Directive as transposed into Irish law by the Habitats Regulations 1997 and under the Wildlife Acts. Any risk to otters or their habitats is permissible only under a derogation license from NPWS. Otters use exposed tree roots as holts, and thus felling riparian trees presents the risk of destroying a holt. Felling a tree and leaving the stump intact (possibly in conjunction with herbicide application to kill the tree) would maintain the root system in the short term and is preferable to complete tree removal. Where removal of the root system is necessary, a specialist mammal survey must be undertaken in order to identify otter holts. It is preferable to carry out holt investigations during winter months due to the absence of dense vegetation which will ensure greater success in identifying holt sites. Where holts are present, a derogation license from NPWS and appropriate mitigation is required.

When undertaking major structural works on a bridge, Fingal County Council should take the opportunity to consider installing a dry-land path for otter to pass under the bridge if no such passage already exists. Where it is not possible to allow a path above flood flow levels between the bridge abutments and the edge of watercourses, a constructed ledge could be provided. Where a dry land path cannot be provided at the base of a bridge, an underpass could be incorporated on one side of the river or ditch. Further guidance on otter ledges and underpasses is provided by the NRA (2007).

Bridge sites are also used by other mammals, such as Badgers, as viable crossing points over stream and river habitats. In general, riparian habitats, particularly treelines and hedgerows, situated nearby and along bridge structures are useful to smaller mammals in crossing watercourses, particularly larger ones. However, this functionality can also lead to instances of road mortality.

Crevices within bridge structures may also supply temporary refuges for smaller mammal species such as House mouse, Wood mouse, Pygmy shrew and Brown rat. However, these were not identified during the daytime site surveys. Other mammals, such as Badger, Hare, Fox and Rabbit can use the environs of bridges. Mammal paths (probably Badger or Fox) were identified in fields adjacent to some of the rivers, particularly within rural areas, and suggest the presence of some of these species.

Birds

Bridges can be important both as nesting sites and roost sites for birds. In addition, the watercourses associated with bridges provide habitat or resources for a number of species. All birds and their nests are protected under the Wildlife Act, 1976 (and Amendment of 2000). In a study of bridge use by bats in Cos. Leitrim and Sligo (Masterson et al., 2008), nesting bird species were also recorded. These included Dipper, Pied Wagtail, Grey Wagtail, Wren, Coal Tit, Blue Tit, Swallow, House Martin and Blackbird. Further species are likely to occur depending on the nature and extent of associated vegetation and levels of disturbance. Additional work on the use of bridges by Dipper is currently ongoing (Copland and Watson, 2008).

Bird species identified during the course of the field surveys included species commonly associated with watercourses. Bird species such as Grey Heron, Little Egret, Moorhen and Grey Wagtail were identified during the field study. Grey Heron was identified within the vicinity of FHBS12 whilst Little Egret was identified in the environs of FHBS07. Both Moorhen and Grey Wagtail were identified near FHBS08.

Typical passerine and other bird species common throughout the Irish countryside were also identified during the bridge surveys. These included Pied Wagtail, Long-Tailed Tit, Blackbird, Pheasant, Song Thrush, Wren, Robin and Blue Tit.

Kingfisher, a species protected under Annex I of the EU Birds Directive, is known from along the Ward River (H. Visser, pers. comm.) and the Broadmeadow River (N. Harmey, pers. comm.).

Nesting potential within and around the environs of each bridge was assessed. This included identifying nearby trees and shrubs with potential for bird nesting. Large mature trees and over-mature trees situated within hedgerows and treelines were highlighted in addition to scrub habitats. Field studies were carried out outside of the bird nesting period, and thus no nesting behaviour was observed.

Installation of nest boxes for Dipper could be considered in conjunction with bridge repair works. This should await the findings of ongoing studies of bridge use by Dipper (Copland and Watson, 2008).

Aquatic fauna

Water quality, fisheries and aquatic organisms are protected under a number of Irish and EU statutes including:

- EU Water Framework Directive (2000/60/EC)
- EU Quality of Fresh Waters to Support Fish Directive (2006/44/EC) updating and consolidating the EU Freshwater Fish Directive (78/659/EEC) and amendments
- EU Habitats Directive (92/43/EEC)
- Fisheries Acts, 1959 to 2003
- Local Government (Water Pollution) Acts, 1977 and 1990

The above legislation places statutory controls on works that take place in and near surface waters that have the potential to negatively affect water quality or the ability of surface waters to support fish and other aquatic fauna. The main body currently responsible in Fingal for maintaining water quality for fisheries is the Eastern Regional Fisheries Board (ERFB), which must consent to any works that have the potential to negatively impact on fish populations[1]. In addition, the NPWS also has a role in the protection of certain aquatic species as detailed below.

Four of the rivers covered by this survey support salmonids (Atlantic Salmon and/or Brown Trout), including the Delvin and its tributaries, the Ballyboughal, the Broadmeadow and the Ward, according to the ERFB. These watercourses need to be passable and navigable throughout the year to satisfy salmonid feeding and breeding requirements. In particular all watercourses need to be passable between the months of October and April in order to facilitate salmonid spawning runs. Bridge structures may facilitate development of temporary barriers through the build up of detritus as the river channel narrows at the bridge underarch. It is an offence under the Fisheries (Consolidation) Act 1959 to 'interfere with or disturb any spawning bed, bank or shallow where the spawn or fry of salmon, trout or eels may be, or to obstruct the passage of salmonid fish'.

The Royal Canal is classed by the ERFB as a cyprinid watercourse. Cyprinid fish (e.g. Bream, Perch, Tench, Rudd and Carp) are common freshwater fish of watercourses. Although no cyprinid species in Fingal are of ecological conservation value, they can be of value to fisheries.

Lampreys, all three species (River Lamprey, Brook Lamprey and Sea Lamprey) of which are listed on Annex II of the Habitats Directive, prefer good water quality, clean substratum at spawning grounds and the presence of fine sediment beds downstream of spawning areas. It has been suggested that heavy siltation and slow currents are unfavourable for larval Lampreys (King and Kelly, 2001). The distributions of Lampreys in Ireland are poorly known, although River and/or Brook Lamprey have been recorded from watercourses in Fingal (Kurz and Costello, 1999; NPWS, 2008). During the field

[1] The structure and responsibilities of the Central and Regional Fisheries Boards are due to change in the near future. In this document, the current and future body with responsibility for fisheries protection in Fingal will be referred to simply as the Fisheries Board.

survey, sections of the Delvin River substrate near Old Mill Bridge (FHBS-02) appeared suitable for juvenile Lamprey due to the abundance of sand in the substrate.

White-clawed crayfish is the only freshwater crayfish species occurring in Ireland. It is widespread in the midlands in areas where the geology is predominantly limestone and has been recorded in the Fingal area in 10 km grid square O04 (Demers et al, 2005). It is now considered a keystone species in Irish freshwater habitats and is protected in Ireland by the Wildlife Act, 1976 and under Annex II of the EU Habitats Directive. Traditionally the White-clawed crayfish has been described as a species sensitive to pollution and considered as a potential bioindicator of water quality. However recent studies carried out in Ireland demonstrate the capacity of this species to live in moderately polluted water (Demers et al, 2005). White-clawed crayfish have not been recorded in the environs of the bridges covered in this survey. However, presence of crayfish remains in an Otter spraint at Cockles Bridge (FHBS-04) indicates that they are present in the vicinity and are likely to be in the Delvin River catchment.

Little information is available on the distribution of other invertebrate species associated with watercourses, some of which may be of conservation interest. However, some work on the fauna of the Royal Canal has previously been done. A review of these studies found that five species of dragonfly and damselfly have been recorded in the vicinity of Callaghan Bridge (FHBS-14) between 1982-1990: hairy dragonfly, brown hawker, common darter, common blue damselfly and blue-tailed damselfly (Dromey et al., 1991). All these species are relatively common and have aquatic larval stages.

Most aquatic fauna require optimal instream conditions such as suitable stream substrates and good water quality. The most natural streams and rivers often see a consistent change or mosaic of water flow ranging from glides to riffles to pools which in turn influence the nature of the substrate. Diversity of flow and substrate has a positive influence on aquatic fauna activity as it supplies a range of feeding and sheltering habitats. Similarly, shading of nearby treelines and hedgerows along stream margins provide shading and food sources for aquatic macroinvertebrate shredder species which specialise in feeding on organic litter, debris and dung.

Concrete is sometimes used to stabilise the substrate of a watercourse underneath bridges, such as FHBS-07, FHBS-08 and FHBS-11 in this survey. Concrete is a poor substrate for aquatic fauna as it provides no variation in in-stream habitats, instead providing a uniform flat habitat which is of limited use to aquatic macroinvertebrates or fish for feeding purposes. Additionally in low flow situations, fish are presented with a thin film of water over a hard, hostile surface arising in circumstances that are not likely to facilitate upstream movement (King, 2007).

Prior to undertaking any instream works the ERFB or its successor Fisheries Board must be notified and an approved method statement of the proposed works must be agreed with the Fisheries Board. All instream works must refer to the ERFB guidelines for the protection of fisheries during construction works (Murphy, 2004) and departmental guidelines for local authority works (DMNR, 1998). In salmonid waters, instream works may not be carried out between the first day of October and the last day of April.

The Fisheries Board must also be consulted prior to repointing or similar works in the vicinity of watercourses, particularly when using lime products. Pollution of river water with lime-based mortar could have serious implications for aquatic fauna and designated sites of conservation importance located down stream of the bridge due to acute increases in the pH of the watercourse.

Major bridge restructuring works must maintain the natural watercourse substrate and flow regimes of riffle, glide and pool. These features are necessary for maintaining a diversity of aquatic fauna, providing salmonid, lamprey and other fish spawning opportunities and for providing feeding opportunities for aquatic fauna and others, including bats. Where natural features have been altered in the past, such as by a concrete apron on the streambed, major restructuring provides an opportunity for rectifying such problems. As a general rule, clear span bridging is preferable to a multispan structure. Where feasible, concrete aprons should be removed; if not feasible or undesirable for engineering reasons, the apron should be dished in the centre so as to provide a channel of deeper water during low-flow. Maintenance of a minimum 50 cm water depth during low-flow conditions should be achieved. If water velocity increases excessively (to greater than 1 metre / second), it will be necessary to install fish passes. The Fisheries Board should be consulted for further guidance on these issues.

Bridge summary

FHBS01 **Gormanstown Bridge**

- This bridge provides suitable bat potential with crevices in the bridge's underarch. Assessment by a bat specialist and consultation with NPWS will be required prior to any repointing, Ivy clearance or other works. A derogation license from NPWS may be required.
- Treelines, both upstream and downstream, provide good commuting routes for bats to and from the bridge and should be retained. Disused bridge in the grounds of Gormanstown College, situated less than 1km to the northwest of the bridge supports very high bat activity (B. Keeley, pers comm.).
- Assessment by a mammal specialist and consultation with NPWS will be required prior to any tree-felling to identify potential Otter holts. A derogation license from NPWS may be required.
- Any tree-felling or Ivy removal should be done in September – October.
- The Delvin River is salmonid, therefore any structural repair works must not impact on water quality or watercourse substrate. In-stream works are not permitted from October through April and must follow a method statement agreed with the Fisheries Board.
- Gormanstown bridge supported a good diversity of plant species that are typically associated with bridges and other stone wall structures, and these should be retained.
- This bridge is located 1.2 km upstream of River Nanny and Estuary Shore SPA. NPWS must be consulted if there is the potential for impacts to the designated site.This bridge provides suitable bat potential with crevices in the bridge's underarch. Inspection by a bat specialist will be required prior to any repointing.

FHBS02 **Old Mill Bridge**

- Sand banks within the river's substrate provide potential habitat for Lampreys, which are listed on Annex II of the EU Habitats Directive; these should be protected from disturbance.
- Dense Ivy growth on the bridge parapet walls provide potential bird and/ or bat nesting or roosting opportunities. Assessment by a bat specialist and consultation with NPWS

will be required prior to any repointing, Ivy clearance or other works. A derogation license from NPWS may be required. Ivy removal should take place in Sept-Oct.

- Treelines dominated by Alder and Ash, upstream of the bridge provide suitable foraging areas for bats in the bridge's vicinity and should be retained.
- The Delvin River is salmonid, therefore any structural repair works on the bridge must not impact on water quality or watercourse substrate. In-stream works are not permitted from October through April and must follow a method statement agreed with the Fisheries Board.
- This bridge is located 5 km upstream of River Nanny and Estuary Shore SPA. NPWS must be consulted if there is the potential for impacts to the designated site.

***FHBS03* Garristown/ Hedge Bridge**

- Some suitable crevices for bat roosting on the downstream side of the bridge's parapet wall. Assessment by a bat specialist and consultation with NPWS will be required prior to any repointing, Ivy clearance or other works. A derogation license from NPWS may be required. Ivy removal should take place in Sept-Oct.
- Ecological connectivity between the bridge and the surrounding habitats limited due to the scarcity of hedgerows and treelines.
- River substrate heavily silted, limiting value for aquatic fauna.
- This stream is situated within the Delvin River catchment which is salmonid, therefore any structural repair works on the bridge must not impact on water quality or watercourse substrate. In-stream works are not permitted from October through April and must follow a method statement agreed with the Fisheries Board.
- This bridge is located 12 km upstream of River Nanny and Estuary Shore SPA. NPWS must be consulted if there is the potential for impacts to the designated site.

***FHBS04* Cockles Bridge**

- Otter activity within the bridge's vicinity confirmed by field survey. Otters are strictly protected under Annexes II and IV of the EU Habitats Directive, and works must maintain passability for Otter. Any works that pose a risk of disturbance to Otters or their habitats require consultation with NPWS and may require a derogation license.
- White clawed crayfish remains identified in Otter spraint – a species protected under Annex II of the EU Habitats Directive.
- A mammal trackway noted within adjacent agricultural grassland.
- The bridge structure contains sufficient crevices and coverage of Ivy in order to support bats. Assessment by a bat specialist and consultation with NPWS will be required prior to any repointing, Ivy clearance or other works. A derogation license from NPWS may be required. Ivy removal should take place in Sept-Oct.
- This stream is situated within the Delvin River catchment which is salmonid, therefore any structural repair works on the bridge must not impact on water quality or watercourse substrate. In-stream works are not permitted from October through April and must follow a method statement agreed with the Fisheries Board.
- This bridge is located 14 km upstream of River Nanny and Estuary Shore SPA. NPWS must be consulted if there is the potential for impacts to the designated site.

***FHBS05* Oldtown Bridge**

- Bat potential of bridge is very low due to structural composition.
- Invasive exotic species (Montbretia and Japanese Knotweed) situated downstream of bridge. Works undertaken on the bridge need to take care that they are not disturbed and spread further along the stream bank. Japanese Knotweed should be eradicated.
- Large mature horse-chestnut trees nearby provide potential bat/ bird roosting/ nesting sites
- Oldtown Bridge is situated on the Ballybougal River catchment which is salmonid, therefore any structural repair works on the bridge must not impact on water quality or watercourse substrate. In-stream works are not permitted from October through April and must follow a method statement agreed with the Fisheries Board.
- River substrate under bridge occupied by concrete apron that should be removed to facilitate passage by salmonids and natural streambed reinstated. If this is not feasible, the concrete apron should be ditched. Works should be undertaken in consultation with the Fisheries Board.
- This bridge is located 10.5 km upstream of Rogerstown Estuary pNHA / cSAC and 13 km upstream of Rogerstown Estuary SPA. NPWS must be consulted if there is the potential for impacts to a designated site.

FHBS06 **Ballyboghill Bridge**

- A previous survey on Ballyboghill Bridge (Natura, 2008) confirmed that no bats or signs of bat activity were recorded at the bridge. The current survey supported the view that Ballyboghill Bridge contained no suitable structural features to support bat species.
- Otters have been recorded in the Rogerstown Estuary and along the tidal river which flows into the estuary (Natura, 2008). The Ballyboughal River, which flows underneath Ballyboghill Bridge, feeds into the tidal river and out into Rogerstown estuary. It is highly likely that Otters feed and commute along the Ballyboughal River as far as the Ballyboghill Bridge. Otters are strictly protected under Annexes II and IV of the EU Habitats Directive, and works must maintain passability for Otter. Any works that pose a risk of disturbance to Otters or their habitats require consultation with NPWS and may require a derogation license.
- Ballyboghill Bridge is situated on the Ballyboughal River catchment which is salmonid, therefore any structural repair works on the bridge must not impact on water quality or watercourse substrate. In-stream works are not permitted from October through April and must follow a method statement agreed with the Fisheries Board.
- This bridge is located 6.5 km upstream of Rogerstown Estuary pNHA / cSAC and 9 km upstream of Rogerstown Estuary SPA. NPWS must be consulted if there is the potential for impacts to a designated site.

***FHBS07* Lispopple Bridge**

- Cover of Ivy on the downstream parapet wall has potential for bird and bat nesting / roosting. Assessment by a bat specialist and consultation with NPWS will be required prior to any Ivy clearance or other works. A derogation license from NPWS may be required. Ivy removal should take place in Sept-Oct.

- Crevices situated on the parapet and on the lower underarch have potential as bat roost sites. Assessment by a bat specialist and consultation with NPWS will be required prior to any repointing or other works. A derogation license from NPWS may be required.
- Presence of Otter confirmed (N. Harmey, pers comm) along this stretch of the Broadmeadow River. Otters are strictly protected under Annexes II and IV of the EU Habitats Directive, and works must maintain passability for Otter. Any works that pose a risk of disturbance to Otters or their habitats require consultation with NPWS and may require a derogation license.
- Lispopple Bridge is situated on the Broadmeadow River which is salmonid; therefore any structural repair works on the bridge must not impact on water quality or watercourse substrate. In-stream works are not permitted from October through April and must follow a method statement agreed with the Fisheries Board.
- River substrate under bridge occupied by concrete apron that should be removed to facilitate passage by salmonids and natural streambed reinstated. If this is not feasible, the concrete apron should be ditched. Works should be undertaken in consultation with the Fisheries Board.
- This bridge is located 6 km upstream of Malahide Estuary pNHA / cSAC and Broadmeadow/Swords Estuary SPA. NPWS must be consulted if there is the potential for impacts to a designated site.

***FHBS08* Roganstown Bridge**

- Presence of Otter confirmed (N. Harmey, pers comm) along this stretch of the Broadmeadow River. Otters are strictly protected under Annexes II and IV of the EU Habitats Directive, and works must maintain passability for Otter. Any works that pose a risk of disturbance to Otters or their habitats require consultation with NPWS and may require a derogation license.
- Bat potential low due to recent pointing of the bridge.
- Roganstown Bridge is situated on the Broadmeadow River which is salmonid; therefore any structural repair works on the bridge must not impact on water quality or watercourse substrate. In-stream works are not permitted from October through April and must follow a method statement agreed with the Fisheries Board.
- River substrate under bridge occupied by concrete apron that should be removed to facilitate passage by salmonids and natural streambed reinstated. If this is not feasible, the concrete apron should be ditched. Works should be undertaken in consultation with the Fisheries Board.
- This bridge is located 5 km upstream of Malahide Estuary pNHA / cSAC and Broadmeadow/Swords Estuary SPA. NPWS must be consulted if there is the potential for impacts to a designated site.

***FHBS09* Mack's Bridge**

- Bird and bat potential on the bridge is limited due to lack of crevices and plant cover.
- Mature trees fringing the river's southern bank provide suitable opportunities for bird nesting, bat roosting and foraging and commuting by these species and should be retained.

- This bridge is located 1.5 km upstream of Malahide Estuary pNHA / cSAC and Broadmeadow/Swords Estuary SPA. NPWS must be consulted if there is the potential for impacts to a designated site.

***FHBS10* Ballymadrough Bridge**

- The Broadmeadow / Swords Estuary SPA and the Malahide Estuary pNHA / cSAC are situated less than 100m downstream of the bridge. Therefore screening and consultation with NPWS to determine need for an Appropriate Assessment of likely impacts on the designated areas will be required prior to any works.
- Dense covering of Ivy on the bridge's parapet walls has potential for suitable bat and bird roosting/nesting habitat. Assessment by a bat specialist and consultation with NPWS will be required prior to any Ivy clearance or other works. A derogation license from NPWS may be required. Ivy removal should take place in Sept-Oct.
- Potential for bat roosting within bridge structure is low due to recent pointing.
- Mosaic of saltmarsh habitats listed on Annex I of the EU Habitats Directive adjacent to stream. Works should avoid damage to these habitats.

FHBS***11* Knocksedan Bridge**

- An area of broadleaved woodland is situated immediately to the north of the bridge. This habitat has the potential to provide suitable bird nesting and bat roosting opportunities and feeding resources for these species within the environs of the bridge structure and should not be disturbed.
- Potential for bat roosting on dense coverage of Ivy on the bridges buttresses. Cover of Ivy on the bridge buttresses has potential for bird and bat nesting / roosting. Assessment by a bat specialist and consultation with NPWS will be required prior to any Ivy clearance or other works. A derogation license from NPWS may be required. Ivy removal should take place in Sept-Oct.
- Previous bat surveys found bridge structure has very good bat potential with 2-3 suitable crevices noted. Species such as Common pipistrelle, Soprano pipistrelle and Daubenton's were confirmed within the vicinity of this bridge (B. Keeley pers. Comm.). Assessment by a bat specialist and consultation with NPWS will be required prior to any repointing or other works. A derogation license from NPWS may be required.
- Otters are known to be present along the Ward River (H. Visser, pers comm). Otters are strictly protected under Annexes II and IV of the EU Habitats Directive, and works must maintain passability for Otter. Any works that pose a risk of disturbance to Otters or their habitats require consultation with NPWS and may require a derogation license.
- Knocksedan Bridge is situated on the Ward River, which is salmonid. Therefore, any structural repair works on the bridge must not impact on water quality or watercourse substrate. In-stream works are not permitted from October through April and must follow a method statement agreed with the Fisheries Board.
- River substrate under bridge occupied by concrete apron that should be removed to facilitate passage by salmonids and natural streambed reinstated. If this is not feasible, the concrete apron should be ditched. Works should be undertaken in consultation with the Fisheries Board.

- This bridge is located 5.5 km upstream of Malahide Estuary pNHA / cSAC and Broadmeadow/Swords Estuary SPA. NPWS must be consulted if there is the potential for impacts to a designated site.

FHBS*12* **Chapelmidway Bridge**

- Crevices nearer the northern side of the underarch have potential as bat roosts. These occur in between jagged vertical rocks. Assessment by a bat specialist and consultation with NPWS will be required prior to any repointing or other works. A derogation license from NPWS may be required.
- Adjacent mature deciduous trees both upstream and downstream of the bridge provide potential to support bat roosts and should be retained.
- Otters are known to be present along the Ward River (H. Visser, pers comm). Otters are strictly protected under Annexes II and IV of the EU Habitats Directive, and works must maintain passability for Otter. Any works that pose a risk of disturbance to Otters or their habitats require consultation with NPWS and may require a derogation license.
- Chapelmidway Bridge is situated on the Ward River, which is salmonid. Therefore, any structural repair works on the bridge must not impact on water quality or watercourse substrate. In-stream works are not permitted from October through April and must follow a method statement agreed with the Fisheries Board.
- Chapelmidway Bridge exhibited a good example of vascular and bryophyte plant species that are typically associated with bridges and other stone wall structures. All structurally non-damaging flora must be retained during bridge restructuring/ repair works.
- This bridge is located 8.5 km upstream of Malahide Estuary pNHA / cSAC and Broadmeadow/Swords Estuary SPA. NPWS must be consulted if there is the potential for impacts to a designated site.

FHBS*13* **Kirkpatrick Bridge**

- The Royal Canal is a pNHA (site code 2103); therefore any works within the vicinity of this designated site must follow a method statement agreed with the NPWS.
- Bat potential of bridge structure is high due to Ivy coverage and extensive treelines adjacent to the canal. A previous survey along this section of the Royal Canal (Keeley, 2004) confirmed bat activity. In particular, the report confirmed the presence of Daubenton's bat, Leisler's bat and common and soprano pipistrelles. Assessment by a bat specialist and consultation with NPWS will be required prior to any repointing, Ivy clearance or other works. A derogation license from NPWS may be required. Ivy removal should take place in Sept-Oct.
- Extensive treeline situated along the margins of the canal should be retained. Ivy coverage on bridge provides suitable bird nesting opportunities. Ivy removal must take place in Sept-Oct following inspection by a bat specialist.
- Kirkpatrick Bridge is situated over the Royal Canal which is a cyprinid watercourse (G. Hannigan, pers comm.). Structural repair works must not impact on water quality.

FHBS*14* **Callaghan Bridge**

- The Royal Canal is a pNHA (site code 2103) therefore any works within the vicinity of this designated site must follow a method statement agreed with the NPWS.

- Ivy coverage on the bridge's parapet and side walls provide suitable bat roosting potential. The treelines fringing the canal also provide suitable foraging areas and should be retained. Assessment by a bat specialist and consultation with NPWS will be required prior to any Ivy clearance or other works. A derogation license from NPWS may be required. Ivy removal should take place in Sept-Oct.
- Crevices within the underarch provide suitable bat roosting potential. Assessment by a bat specialist and consultation with NPWS will be required prior to any repointing or other works. A derogation license from NPWS may be required.
- A previous survey along this section of the Royal Canal (Keeley, 2004) confirmed bat activity along this stretch. In particular, the report confirmed the presence of Daubenton's bat, Leisler's bat, common and soprano pipistrelles.
- Callaghan Bridge is situated over the Royal Canal which is a cyprinid watercourse (G. Hannigan, pers comm.). Structural repair works must not impact on water quality.

FHBS*15* **Collins Bridge**

- The Royal Canal is a pNHA (site code 2103) therefore any works within the vicinity of this designated site must follow a method statement agreed with the NPWS.
- A previous survey along this section of the Royal Canal (B. Keeley, 2004) confirmed bat activity. In particular, the report confirmed the presence of Daubenton's bat, Leisler's bat and common and soprano pipistrelles.
- Assessment by a bat specialist and consultation with NPWS will be required prior to any repointing, Ivy clearance or other works. A derogation license from NPWS may be required. Ivy removal should take place in Sept-Oct.
- Large trees associated with a treeline situated upstream of the bridge provide suitable bird nesting opportunities and should be retained.
- Treelines associated with private dwellings situated to the north of the bridge provide suitable wildlife corridors for mammals and birds and should not be disturbed.
- Collins Bridge is situated over the Royal Canal which is a cyprinid watercourse (G. Hannigan, pers comm.). Structural repair works must not impact on water quality.

6. *Towards integrated conservation of masonry bridges*

As discussed previously in this document, the road network in Fingal, as in any other populated area of Ireland is heavily dependant on a large number of historic masonry bridges and culverts, the majority of which follow the stone arch method of construction. In addition to the essential logistical contribution which these structures make to everyday road communication, is the built heritage significance of historic bridges which can form an important element of the full understanding of the architectural, technical, artistic, social, and historical character of a local area or region. Finally, bridges, especially in rural areas or small settlements, often represent the closest point of interaction between the human population and the natural habitat of the watercourse they span. Apart from often providing habitat opportunities associated with their structures, bridges are a principal focus of human activity which can have effects on potentially sensitive natural heritage within the ecosystem of the river or canal associated with them.

Lessons from this study
As a result of the research carried out for this present study of bridges in Fingal, the following key points were noted as having relevance to ongoing bridge conservation programmes:

- Surveying to assess conservation and maintenance needs of individual structures is most efficiently undertaken by an ecologist and built heritage expert in one site visit.

- Use of a structured recording sheet for both ecological and built heritage information, with a standardised set of views recorded photographically, provides a comprehensive and useful record which allows comparison of structures using compatible data.

- Sufficient training and familiarisation of those County Council staff charged with bridge maintenance is essential so that appropriate assessment of each structure is carried out as standard practice. This will ensure that legal designations are observed and factored into proposed works at the initial stages and also that works are appropriately assessed to maximise sustainability of any operations.

These conclusions were reached following consideration of the merits of how research was carried out for the present pilot study. The input of structural engineers was found to be relatively unnecessary provided sufficient assessment of bridges has been carried out by appropriately experienced built and natural heritage personnel. This was largely due to the fact that the majority of protective legislation relevant to historic bridges is likely to be more familiar to such professionals. The structural integrity of these bridges is invariably a function of the condition of the various elements of the structures and provided these are repaired and maintained to the best practice standards outlined in this study, there is little reason for any bridge, subject to its rated loading, not to continue performing as well as it has since construction.

Understanding historic bridge construction
For historic bridges to be retained in use, as many have in Fingal for up to eight centuries, the proven methods of construction and repair must be fully understood and continued, not just from a historic integrity perspective but also to ensure the continued performance of the structures. Despite the

dramatic increase in the loads masonry bridges are required to carry since they were first constructed, many are fully capable of continuing to support the modern volumes of traffic provided appropriate and timely maintenance and conservation is carried out as necessary.

To ensure that maintenance of these structures is conducted in the right way, a seminar for all relevant County Council staff should be organised with the aim of instilling the appropriate conservation philosophy and correct techniques in those with responsibility for looking after the stock of masonry bridges. It is vital to stress to staff, the particular importance of lime mortar used in the correct way to counter the effects of thermal movement and live loading of traffic as well as reducing ingress and facilitating the escape of water which will inevitably enter the structure through defects, particularly due to poor road drainage or ill-designed verges.

Repair priorities

Individual bridges and each of the different structural elements (parapets, arch barrels, spandrels etc. discussed further in Chapter 4) need to be examined in terms of what repair, if any is required. A particular lime mortar suitable for the repair of one element may not be appropriate for another and explanation of the factors which lead to these determinations should be a key part of seminars for maintenance staff. As mentioned in Chapter 4, the National Roads Authority Bridge Management Group (Republic of Ireland) have experimented, tested and run trials on using lime mortars to repair bridges and have produced a specification for undertaking repointing using lime mortar. If contractors do not have direct experience of using lime mortar then they should receive training in this type of work before being considered in addition to the general training provided by the conservation seminar.

The road surfacing and verges of individual bridges, like the roof and rainwater goods of any building are fundamental to the condition of the structure and their maintenance is therefore of paramount importance to protect the load-bearing structure below. Often, the upper parts of bridges has been treated with the same methods as other stretches of road being maintained, but the integrity of the trafficable surface, the drainage of verges and the collision minimisation measures should receive careful and regular attention to ensure they are of a good standard. In many cases, proper maintenance programmes for bridge surfaces have not been in place and it may be necessary to reconstruct the road surface completely to ensure that structural damage to the bridge through normal use is arrested and that ongoing low-level maintenance is sufficient to conserve the entire structure into the future. Such reconstruction of road surfaces over bridges could be undertaken to one side of the road surface at a time to enable use of the crossing by traffic to continue, albeit restricted. For the average single or double stone-arch bridge with a total span of around five metres supporting a standard width two-way regional road, this reconstruction should feature the following steps:

- Cutting and removal (preferably by means other than use of heavy hammer-action equipment) of existing road surface, foundation verge material and spandrel fill down to the extrados of the stone arch barrel.

- The arch barrel should then be levelled with stone pinnings pushed gently (not hammered or forced) into spaces between arch stones to provide the maximum possible stability to the arch. A further bed of sand should be applied to support a semi-permeable membrane sheet over the arch barrel and extending up the spandrel walls to the base of the parapets.

- The spandrels should again be filled with a mix of stone and aggregate packed to a stable foundation for the new road surface. Verge drainage channels and piping to take rain water off the bridge surface to suitable treatment on the bridge approaches should be installed as part of the reconstruction works.

- Appropriately designed sloped kerbs should be installed to the sides of the new road surfaces unless there is space for a pedestrian footpath. These are to prevent the majority of minor road traffic collisions with the parapet walls and also to create a solid surface incorporating road drainage connected to a pipe network which will prevent ingress of water through former soft road margins. These margins were often previously subject to vehicles driving over them, causing arch fill to be compressed out of position or forced against the spandrel walls leading to destabilisation of these. As well as being moisture permeable areas which allowed water from poorly drained bridges to penetrate the structure these soft margins and verges were often inadequately maintained and vegetation such as trees and ivy were allowed to become established causing further damage with their root systems.

The ongoing maintenance elements of historic bridge conservation will encompass many of the individual recommendations made for the bridges in *table 3*, Chapter 6. Control of damaging vegetation especially trees or ivy rooted on bridges, re-pointing of mortar joints on vertical surfaces and the arch soffit to consolidate the structure as well as to restrict the ingress of moisture and the potential for vegetation to take root, and necessary repair to parapet cappings or other horizontal surfaces designed to protect the structures beneath are the most regular requirements of historic bridges observed as part of this study. These relatively simple operations should be among the most common items of maintenance necessary to keep a historic bridge with no other significant defects in good condition.

More significant repair works may involve the taking down and re-building of parts of parapet walls, abutments or spandrels, pinning or adding voussoirs to arch intrados, tying running collar joints on arch faces or the complete renewal of the bridge's upper surface as described above. These repairs may have resulted from lack of routine maintenance but can also have arisen from defects in the original construction such as settlement of foundations or fill material or misalignment of stones which might only have become apparent since normal weathering washed out the pointing mortar which could have concealed this damage. Damage from serious flooding or road traffic collisions can have serious consequences for these masonry structures and this is another item of bridge condition to be assessed on an individual basis as part of the standardised recording process.

Natural Heritage

As discussed in a number of sections in this report, bridges provide a habitat for many protected species, particularly bats, birds, fish, otters and insects. The presence and nature of sensitive species inhabiting bridges and their environs must be taken into account when planning any works to structures, with all staff being made aware of the indicative signs and restrictions that statutory protection of particular flora and fauna demands. This will include awareness of the bodies such as the National Parks and Wildlife Service or the Fisheries Boards that must be contacted prior to conducting any work on protected habitats. The restrictions on chemical use, seasonal restrictions on work so as not to disturb hibernation or breeding patterns of protected species and the measures that can be taken to ensure the habitats are retained while still ensuring the conservation of the bridge structure are discussed at length in this report and can also be explained by the relevant bodies such as those named above.

The particular risks associated with using lime to repair bridges can be addressed using appropriate plastic sheeting and due care by contractors to ensure that lime does not enter the water course below to alter the pH and present serious risk to fish populations.

Implementation of recommendations

It has been concluded from the experience gathered for this initial bridge survey that the standardised recording procedure with the stated built and natural heritage personnel should be rolled out to take in the entire stock of historic bridges under the administration and responsibility of Fingal County Council. This will highlight the structures at risk, prioritise where repair and maintenance is required and quantify the condition of the entire historic bridge stock in the Council area.

Following the details gathered in this initial survey, the research into proper maintenance and management of masonry bridges and the insight gained from those engaged in the upkeep of historic bridges in other areas, a pro-active recommendation of establishing a small dedicated mobile bridge maintenance unit would represent an extremely effective way of prolonging the useful lifespan of such historic structures in Fingal. Given appropriate training and possibly supervision for an initial period, a team of as few as two dedicated bridge maintenance workers equipped with a small mobile works units of materials, mortar mixer and other equipment could conceivably manage the vast majority of the historic bridges in the Council area which do not require major specialist intervention but can be retained serving their purpose for the foreseeable future given targeted low-level maintenance. This may involve vegetation removal, selective pointing, clearing drainage gullies or any of the repair and maintenance tasks detailed on *Table 4* below. Staff on such a team could be informed of the consents, priorities and relevant procedures required for each structure from a suitably devised database of survey results which may be based on the template provided with this report and this bank of information would also be a planning tool to highlight the location of bridges in need of such basic attention.

7. Conclusions and recommendations

Built Heritage Recommendations

The following *Table 4* summarises the priorities and issues generalised in sections 4 and 5 above, which apply to the individual bridges surveyed. The bodies noted such as the relevant local authorities, Department of Environment, Heritage and Local Government, Fisheries Board or the National Parks and Wildlife Service should be consulted prior to works to determine if consent is needed or not. **Urgent** work (in bold type) should be attended to as soon as possible and preferably within the next twelve months. *Medium* term priorities (in italics) should be considered within one to three years and longer term issues (in normal type) should be part of a five-year plan for the management of the bridge. Maintenance of road drainage and control of vegetation on verges which directly affect the bridge structure should be an ongoing process on every bridge where relevant.

Measures which should be taken to safeguard the natural heritage value of bridges and their environs during the course of necessary bridge structural works and vegetation control are also presented in *Table 4*. We also present recommendations for works to enhance the ecology associated with bridges. These and more general measures are discussed in detail in Chapter 5.

As discussed above, several aspects of the natural heritage of bridges, including habitats, species and water quality, are protected by Irish and European law. Therefore, approval for works will frequently be required from external agencies, such as the NPWS and the Fisheries Board, and supervision of works by ecological specialists will often be necessary. These requirements are indicated in *Table 4*. Although compliance with environmental legislation can be onerous or complex, failure to understand legal requirements is **not** an adequate defense for any actions which lead to breach of a site's statutory protection. When a bridge is potentially of natural heritage importance, the Fingal County Council Biodiversity Officer should always be consulted prior to commencing works.

Legislation of relevance to the ecology of bridges includes, but is not limited to:

- EU Habitats Directive (92/43/EEC);
- EU Birds Directive (79/4089/EEC);
- Wildlife Act, 1976 and the Wildlife (Amendment) Act, 2000;
- Flora (Protection) Order, 1999;
- EU Water Framework Directive (2000/60/EC);
- EU Quality of Fresh Waters to Support Fish Directive (2006/44/EC) updating and consolidating the EU Freshwater Fish Directive (78/659/EEC) and amendments;
- Fisheries Acts, 1959 to 2003; and
- Local Government (Water Pollution) Acts, 1977 and 1990.

We recommend that the database of bridge heritage begun by this project be expanded in later years to eventually encompass all bridges in Fingal County Council's remit. The natural heritage aspects of this database should be reviewed and updated every five years.

Table 4: Recommendations for conservation repairs

Bridge & Reference Number	Consents required for works	Ecological issues	Key areas of repair and priority with which these should be addressed
Gormanstown Bridge *FHBS01*	Local Authority (Meath and Fingal County Councils) and DoEHLG Obtain Fisheries Board approval for herbicide use, use of lime mortar and all in-stream works (only permitted Oct-April)	• Tree-felling and ivy removal during Sept-Oct • Retain riparian vegetation • Retain non-damaging bridge flora • Mammal specialist to identify possible otter holts prior to tree removal; derogation license may be required • Assessment by bat specialist and consultation with NPWS prior to ivy removal and/or repointing; derogation license may be required • Maintain natural river substrate	• **Removal of tree growing on upstream cutwater** • *Removal of tree growing underneath downstream cutwater* • *Removal of ivy from parapet walls* • Re-pointing of masonry joints where necessary to prevent vegetation taking root • Replacement of cement pointed mortar joints with appropriate lime mortar
Old Mill Bridge *FHBS02*	Local Authority (Meath and Fingal County Councils) Obtain Fisheries Board approval for herbicide use, use of lime mortar and all in-stream works (only permitted Oct-April)	• Ivy removal during Sept-Oct • Retain riparian vegetation • Assessment by bat specialist and consultation with NPWS prior to ivy removal and/or repointing; derogation license may be required • Maintain natural river substrate	• *Consolidation or re-building of stone parapet capping* • *Removal of ivy rooted on structure* • Re-pointing of masonry joints where necessary to prevent vegetation taking root
Garristown Bridge *FHBS03*	Local Authority Obtain Fisheries Board approval for herbicide use, use of lime mortar and all in-stream works (only permitted Oct-April)	• Ivy removal during Sept-Oct • Assessment by bat specialist and consultation with NPWS prior to ivy removal and/or repointing; derogation license may be required	• *Pointing of weathered mortar joints using lime mortar and pinnings to secure poorly tied face stones* • *Removal of ivy rooted on structure*
Cockles Bridge *FHBS04*	Local Authority Obtain Fisheries Board approval for herbicide use, use of lime mortar and all in-stream works (only permitted Oct-April)	• Ivy removal during Sept-Oct • Retain riparian vegetation • Assessment by bat specialist and consultation with NPWS prior to ivy removal and/or repointing; derogation license may be required • Works must maintain passability for Otter; derogation license may be required • Maintain natural river substrate	• *Re-bedding of parapet capping stones dislodged from bridge* • *Removal of ivy rooted on structure*
OldTown Bridge *FHBS05*	Obtain Fisheries Board approval for herbicide use, use of lime mortar, cement or paint and all in-stream works (only permitted Oct-April)	• Ivy removal during Sept-Feb • Retain riparian vegetation • Eradicate nearby Japanese knotweed population and do not cause spread of this species or Montbretia • Reinstate natural streambed within the bridges underarch in consultation with the Fisheries Board	• *Painting of steel arch soffit as part of ongoing maintenance programme* • *Removal of ivy rooted on structure*
Ballyboghill Bridge *FHBS06*	Obtain Fisheries Board approval for herbicide use, use of lime mortar and all in-stream works (only permitted Oct-April)	• Works must maintain passability for Otter; derogation license may be required • Maintain natural river substrate	• **Grouting of cracks in concrete to prevent water ingress corroding steel reinforcement.**
Lispopple Bridge *FHBS07*	Local Authority Obtain Fisheries Board approval for herbicide use, use of lime mortar and all in-stream works (only permitted Oct-April)	• Ivy removal during Sept-Oct • Retain riparian vegetation • Assessment by bat specialist and consultation with NPWS prior to ivy removal and/or repointing; derogation license may be required • Maintain natural river substrate • Works must maintain passability for Otter; derogation license may be required • Reinstate natural streambed within the bridges underarch in consultation with the Fisheries Board •	• **Removal from river channel of tree branches and other debris caught on upstream side of bridge** • *Removal of ivy rooted on structure* • *Monitoring of east abutment where bulge is apparent*

Bridge & Reference Number	Consents required for works	Ecological issues	Key areas of repair and priority with which these should be addressed
Roganstown Bridge *FHBS08*	Local Authority, DoEHLG and private owners Obtain Fisheries Board approval for herbicide use, use of lime mortar and all in-stream works (only permitted Oct-April)	• Retain riparian vegetation • Maintain natural river substrate • Works must maintain passability for Otter; derogation license may be required • Reinstate natural streambed within the bridges underarch in consultation with the Fisheries Board	• Replacement of cement pointed mortar joints with appropriate lime mortar
Mack's Bridge *FHBS09*	Local Authority and DoEHLG Obtain Fisheries Board approval for herbicide use	• Tree-felling during Sept-Oct • Retain riparian vegetation • Mammal specialist to identify possible otter holts prior to tree removal; derogation license may be required	• *Removal of tree rooted beneath upstream abutment*
Ballymadrough Bridge *FHBS10*	Local Authority, DoEHLG and private owners Obtain Fisheries Board approval for herbicide use Screening and consultation with NPWS required to determine need for Appropriate Assessment of likely impacts to nearby designated area prior to any works	• Tree-felling and ivy removal during Sept-Oct • Avoid disturbance to adjacent saltmarsh • Retain riparian vegetation • Retain non-damaging bridge flora • Assessment by bat specialist and consultation with NPWS prior to ivy removal and/or repointing; derogation license may be required • Maintain natural river substrate	• *Removal of tree rooted on bridge top* • *Removal of ivy rooted on structure* • *Pointing of weathered mortar joints particularly those at water level with appropriate mortar*
Knocksedan Bridge *FHBS11*	Local Authority and DoEHLG Obtain Fisheries Board approval for herbicide use, use of lime mortar and all in-stream works (only permitted Oct-April)	• Tree felling/ removal and Ivy removal during Sept-Oct • Retain riparian vegetation • Retain non-damaging bridge flora • Assessment by bat specialist and consultation with NPWS prior to ivy removal and/or repointing; derogation license may be required • Works must maintain passability for Otter; derogation license may be required • Reinstate natural streambed within bridge's underarch in consultation with the Fisheries Board.	• **Removal of trees rooted on buttress tops and re-building of masonry here following removal of roots** • *Redesign of road drainage to prevent oil-contaminated water washing over masonry* • *Removal of ivy rooted on structure* • Replacement of cement pointed mortar joints with appropriate lime mortar
Chapelmidway Bridge *FHBS12*	Obtain Fisheries Board approval for herbicide use, use of lime mortar and all in-stream works (only permitted Oct-April)	• Retain riparian vegetation • Tree felling and Ivy removal during Sept-Oct • Assessment by bat specialist and consultation with NPWS prior to ivy removal and/or repointing; derogation license may be required • Works must maintain passability for Otter; derogation license may be required • Retain non-damaging bridge flora • Maintain natural river substrate	• *Removal of trees rooted on approach walls and parapets and reinstatement of coping stones* • *Removal of ivy rooted on structure* *See engineering recommendations for this bridge in earlier section of report.* .
Kirkpatrick Bridge *FHBS13*	Local Authority Obtain NPWS approval before commencing works on the bridge structure Obtain Fisheries Board approval for herbicide use, use of lime mortar and all in-stream works (only permitted Oct-April)	• Retain riparian vegetation • Ivy removal during Sept-Oct • Assessment by bat specialist and consultation with NPWS prior to ivy removal and/or repointing; derogation license may be required	• *Removal of ivy rooted on structure* Reduce road surface height to ensure carved name plaque is not obscured.

Bridge & Reference Number	Consents required for works	Ecological issues	Key areas of repair and priority with which these should be addressed
Callaghan Bridge *FHBS14*	Local Authority Obtain NPWS approval before commencing works on the bridge structure Obtain Fisheries Board approval for herbicide use, use of lime mortar and all in-stream works (only permitted Oct-April)	• Retain riparian vegetation • Tree felling and Ivy removal during Sept-Oct • Assessment by bat specialist and consultation with NPWS prior to ivy removal and/or repointing; derogation license may be required	• *Removal of ivy rooted on structure* • *Consider re-building previously repaired parapet walls using appropriate stone and mortar to match the remaining historic sections.* *See engineering recommendations for this bridge in earlier section of report.*
Collins Bridge *FHBS15*	Local Authority Obtain NPWS approval before commencing works on the bridge structure Obtain Fisheries Board approval for herbicide use, use of lime mortar and all in-stream works (only permitted Oct-April)	• Retain riparian vegetation • Ivy removal during Sept-Oct • Assessment by bat specialist and consultation with NPWS prior to ivy removal and/or repointing; derogation license may be required	• *Removal of ivy rooted on structure*

Bridge structural works

Bats are protected under the Wildlife Acts and the EU Habitats Directive. Prior to undertaking any maintenance or restructuring works on bridges with potential to support roosting bats, a bat survey of each bridge must be undertaken by a bat specialist. This is necessary to prevent damaging bats or entombing them during repointing. If bats are found to be roosting in a bridge, a derogation license will be required from NPWS to undertake works that reduce or eliminate the use of the bridge as a roost. A derogation license will generally require detailed proposals for mitigation of any negative impacts. Such measures can include the incorporation of bat boxes or bat tubes in the bridge fabric. Additional guidance on bat mitigation is provided by Kelleher and Marnell (2006). In general, works to be undertaken on bridges should follow the NRA's Best Practice Guidelines for the Conservation of Bats (2005) and Guidelines for the Treatment of Bats (2006).

Water quality, fisheries and aquatic organisms are protected under a number of Irish and EU statutes as noted above. The ERFB is currently the statutory body responsible for protection of fisheries in Fingal. As noted above, the Central and Regional Fisheries Boards will be undergoing restructuring in the near future. Prior to undertaking any instream works the ERFB or its successor Fisheries Board must be notified and an approved method statement of the proposed works must be agreed with the Fisheries Board. All instream works must refer to the ERFB guidelines for the protection of fisheries during construction works (Murphy, 2004) and departmental guidelines for local authority works (DMNR, 1998). In salmonid waters, instream works may not be carried out between the first day of October and the last day of April.

The Fisheries Board must also be consulted prior to repointing or similar works in the vicinity of watercourses, particularly when using lime products. Pollution of river water with lime-based mortar could have serious implications for aquatic fauna due to acute increases in the pH of the watercourse.

Major bridge restructuring works must maintain the natural watercourse substrate and flow regimes of riffle, glide and pool. These features are necessary for maintaining a diversity of aquatic fauna, providing salmonid, lamprey and other fish spawning opportunities and for providing feeding opportunities for aquatic fauna and others, including bats. Where natural features have been altered in the past, such as by a concrete apron on the streambed, major restructuring provides an opportunity for rectifying such problems. As a general rule, clear span bridging is preferable to a multispan structure. Where feasible, concrete aprons should be removed; if not feasible or undesirable for engineering reasons, the apron should be dished in the centre so as to provide a channel of deeper water during low-flow. Maintenance of a minimum 50 cm water depth during low-flow conditions should be achieved. If water velocity increases excessively (to greater than 1 metre / second), it will be necessary to install fish passes. The Fisheries Board should be consulted for further guidance on these issues.

Works within sites designated for nature conservation will require approval of the NPWS. In addition, works that have the potential to impact on designated areas downstream will also require NPWS approval. As a general guide, we recommend that minor works less than 1 km upstream of designated areas and major works further upstream of designated areas will also require consultation. Designated areas include NHAs, SACs and SPAs. Of the bridges in this study, the NPWS will need to be consulted prior to any works on the three bridges situated over the Royal Canal pNHA (FHBS13, FHBS14 and FHBS15) and on Ballymadrough Bridge (FHBS10), which is situated less than 100m upstream of the Malahide Estuary pNHA/ cSAC and the Broadmeadow/Swords Estuary SPA. Where there is a potential for negative impacts on the conservation objectives of Natura 2000 sites (SACs and SPAs), screening will be required to determine the need for an Appropriate Assessment under Article 6 of the EU Habitats Directive. According to Article 6(3) of the Habitats Directive, "any plan or project not directly connected with or necessary to the management of the site but likely to have a significant effect thereon either individually or in combination with other plans or projects, shall be subject to Appropriate Assessment of its implications for the site in view of the site's conservation objectives" (European Commission, 2002).

When undertaking major structural works on a bridge, Fingal County Council should take the opportunity to consider installing a dry-land path for Otter to pass under the bridge if no such passage already exists. Where it is not possible to allow a path above flood flow levels between the bridge abutments and the edge of watercourses, a constructed ledge could be provided. Where a dry land path cannot be provided at the base of a bridge, an underpass could be incorporated on one side of the river or ditch. Further guidance on Otter ledges and underpasses is provided by the NRA (2007).

Installation of nest boxes for Dipper could be considered in conjunction with bridge repair works. This should await the findings of ongoing studies of bridge use by Dipper (Copland and Watson, 2008).

Provision of lighting at bridges must ensure that no light reaches watercourses to reduce impacts on Otters, bats and other species. Similarly, lights must not be directed at the sides of bridges to permit the establishment or maintenance of bat roosts. Where lighting is necessary, directional lighting and full cut-off lighting (where no light is permitted to escape above the horizontal level of the lamp) should be employed.

Vegetation control

Plant species which are considered to be structurally damaging to bridge habitats are highlighted in *Table 3*. These include mature and semi-mature trees situated beside the bridges, and trees, shrubs, climbers and other species with stout rootstocks or rhizomes, such as Ivy, Red valerian and Butterfly bush. Most of the bridges within the study area supported Ivy which was often identified in dense patches of growth on bridge parapet walls. The roots and rhizomes of these species can damage the fabric of bridges by gradually growing between the joints of the bridge, thereby altering and effectively damaging the structural integrity of the bridge.

Lichens, mosses, liverworts and smaller vascular plants, such as ferns, Ivy-leaved toadflax and Pellitory-of-the-wall, have much finer rhizomes and roots that cause minimal damage to bridge fabrics. Many of these are characteristic wall species of ecological interest, and bridges can rarely support protected (under the Flora (Protection) Order, 1999) or endangered species. Therefore, non-damaging wall flora must be maintained where possible; however, if removal of non-damaging species is necessary, this should only be done with the approval of the Fingal Biodiversity Officer. Practices such as spraying of entire bridge surfaces with herbicide are not permissible. Where extensive clearance of non-damaging species is necessary, a botanical survey should be conducted to ensure that no legally protected or rare species are affected.

Mechanical means of vegetation control on bridges are preferable to chemical methods. Broadcast spraying of herbicide can negatively impact non-damaging flora as discussed above and can also have serious water quality impacts. Trees can be felled and Ivy can be severed at the base where it roots into the soil.

Where herbicide use is considered necessary, the Fisheries Board must be consulted prior to the use of herbicides on bridge structures. The type of herbicide used, in addition to the dilution/ volume of herbicide used, must be in compliance with the Fisheries Board best practice. Currently the Central Fisheries Board (CFB) use Roundup Pro Biactive, a glyphosate-based herbicide that controls weeds by blocking the plant's enzyme system. This herbicide is one of the few herbicides that has been authorised for use within waterbodies (Joe Caffrey, CFB, pers. comm.). Preferably herbicide application will be used in conjunction with mechanical control. This will involve the initial cutting of the plant stem before directly treating the remaining stump and root vegetation with herbicide. This will allow for a reduced herbicide use in addition to directly targeting the root of each plant. This method of treatment will minimise potential run-off into watercourses and will require less herbicide use overall.

According to Section 46 of the Wildlife (Amendment) Act, 2000, "1(a) It shall be an offence for a person to cut, grub, burn or otherwise destroy, during the period beginning on the 1st day of March and ending on the 31st day of August in any year, any vegetation growing on any land not then cultivated. (b) It shall be an offence for a person to cut, grub, burn or otherwise destroy any vegetation growing in any hedge or ditch during the period mentioned in paragraph (a) of this subsection." It is unclear whether this section applies to vegetation on bridges, and there are several exceptions to this prohibition which may or may not apply to bridge maintenance. Nevertheless, to protect nesting birds and mammal habitation, tree felling and Ivy or other vegetation clearance should not be performed during the summer period, unless surveys have been undertaken to ensure lack of occupation.

Due to the potential for bat roosting in trees and Ivy, a bat specialist must be consulted prior to clearance of dense Ivy growth and felling of trees adjacent to bridges. It is preferable that tree felling be carried out prior to the period of bat hibernation and subsequent to the breeding period and bird nesting period. This would indicate September and October as the best period within which to clear vegetation, following inspection by a bat specialist. Where bats are noted to be within a tree or Ivy prior to felling or clearance, it will be necessary to postpone felling to create the opportunity for bats to cease usage. If bats do not leave a tree or bridge within a reasonable time, it may be possible for a bat specialist to exclude the bats or otherwise remove them. This must be carried out by a qualified bat specialist with a derogation license from NPWS. As noted above, mitigation in the form of bat boxes or tubes may be required.

Riparian vegetation within the immediate vicinity of the bridges must be retained where possible, and bridge works must take account of opportunities for integrating the bridge habitats, flora and fauna with habitats and land use in the wider landscape. Riparian zone vegetation provides valuable ecological connectivity, feeding and nesting/roosting opportunities in landscapes dominated by intensive agricultural practices and human activity. It provides important functions in regulating watercourse temperature and other functions. Riparian vegetation provides a viable buffering function by trapping and retaining run-off from nearby habitats which contributes to an overall increase in water quality. In the event of riparian zone removal the resultant soil and bare ground habitats need to be stabilised with suitable mitigation measures taken against any sediment mobilisation into the watercourse. Silt fencing and silt traps should be erected to collect any mobilised suspended material.

Where riparian vegetation is currently absent or patchy, there is an opportunity to enhance ecological connectivity and conservation value in the vicinity of bridges by planting trees and shrubs. Planted species should be native to Fingal and characteristic of Fingal watercourses. Suitable tree species include Alder, Downy Birch and Rusty Sally, and suitable shrubs include Hazel, Hawthorn, Blackthorn and Holly. Where they are characteristic of a particular stretch of watercourse, long-naturalised willow species such as Crack Willow, White Willow, Osier and Purple Osier may be suitable. Advice on species and planting should be sought from an ecologist or similar professional with expertise in native habitat restoration.

Works on bridges near where invasive, non-native plant species, such as Japanese Knotweed and Giant Hogweed, occur must not contribute to the spread of these plants. Promoting the spread of invasive, non-native species is an offence under the Wildlife (Amendment) Act, 2000. In general, works should not take place near invasive species during fruiting so as to minimise risk of spreading seeds or fruits. Disturbed areas near invasive plants should be minimised. Vehicles and other equipment used in the vicinity of invasive plants must be washed prior to use at other sites. Soil from areas near invasive plants must not be translocated to other areas. Where possible, populations of invasive plant species should be eradicated. Further guidance on controlling invasive plant species is available through Invasive Species Ireland (www.invasivespeciesireland.com).

Vegetation clearance and structural works in the environs of bridges must also avoid the disturbance and/or destruction of Otter holts. Otters are protected under the Wildlife Acts and the EU Habitats Directive. Otters use exposed tree roots as holts, and thus felling riparian trees presents the risk of destroying a holt. Felling a tree and leaving the stump intact (possibly in conjunction with herbicide application to kill the tree) would maintain the root system in the short term and is preferable to complete tree removal. Where removal of the roots system is necessary, a specialist mammal survey must be undertaken in order to identify Otter holts. It is preferable to carry out holt investigations during winter months due to the absence of dense vegetation which will ensure greater success in identifying holt sites.

8. References

Aalen, F., Whelan, K., and Stout, M. (1997) *Atlas of the Irish Rural Landscape.* Cork University Press, Cork.

Andrews, J.H. (1964) *Road Planning in Ireland before the Railway Age* in *Irish Geography v.* pp.17-41.

Atkins and John Cronin and Associates (2007) *Cork City Bridges Study.* Report prepared for Cork City Council.

Barry, M. (1985) *Across Deep Waters: Bridges of Ireland.* Frankfurt Press, Dublin.

BEC Consultants (2004) *A Study of the Royal Canal Vascular Plant Flora.* Report prepared for Waterways Ireland.

Billington, G. E. and Norman, G. M. (1997) *The Conservation of Bats in Bridges Project: A Report on the Survey and Conservation of Bat Roosts in Bridges in Cumbria.* English Nature, Kendal.

Broderick, D. (1996) *An Early Toll Road: The Dublin-Dunleer Turnpike 1731-1855.* Irish Academic Press, Dublin

Clarke, P. (1992) *The Royal Canal: The Complete Story.* ELO Publications, Dublin.

Copland, A.S. and Watson, D. (2008) *Aspects of the ecology of the Dipper Cinclus cinclus in the Slieve Bloom Mountains.* In: Current Ornithological Research in Ireland: 5th Ornithological Research Conference, UCC November 2008. Irish Birds 8: 13.

Cox, R. (ed.) (2006) *Engineering Ireland.* Collins Press, Cork.

Cox, R. and Gould, M. (2003) *Ireland's Bridges.* Wolfhound Press, Dublin.

(1998) *Civil Engineering Heritage.* Institution of Civil Engineers, Dublin.

Curtis, T.G.F. and McGough, H.N. (1988). *The Irish Red Data Book. 1 Vascular Plants.* The Stationery Office, Dublin.

Delany, R. (2004) *Ireland's Inland Waterways.* Appletree Press, Belfast.

Demers, A., Lucey, J., McGarrigle, M.L. and Reynolds, J.D. (2005) *The distribution of the white-clawed crayfish, Austropotamobius pallipes, in Ireland.* Biology and Environment 105B: 65-69.

Department of the Marine and Natural Resources (DMNR) (1998) *Fisheries Guidelines for Local Authority Works.* DMNR, Dublin.

Doogue, D. Nash, D. Parnell, Reynolds J and Jackson, P.W. (1998) *Flora of County Dublin.* The Dublin Naturalists Field Club, Dublin.

Dromey, M., Johnston, B. and Nairn, R. (1991) *Ecological Survey of the Royal Canal. Part 1: Survey Report.* Report prepared for the Wildlife Service and Waterways Section, Office of Public Works.

Environment and Heritage Service (EHS) and National Parks and Wildlife Service (NPWS) (2008) *All-Ireland Species Action Plan: Bats.* EHS and NPWS, Belfast and Dublin.

European Commission (2002) *Assessment of Plans and Projects Significantly Affecting Natura 2000 Sites: Methodological Guidance on the Provisions of Article 6(3) and (4) of the Habitats Directive 92/43/EEC.* European Communities, Luxembourg.

European Commission (2007) *Interpretation Manual of European Union Habitats. EUR 27.* European Commission, DG Environment.

Fossitt, J.A. (2000) *A Guide to Habitats in Ireland.* The Heritage Council, Kilkenny.

Gilbert, J.T. (1874) *4th Report of the Royal Commissioners on Historic Manuscripts.*

Joyce, J. (1920) *The Neighbourhood of Dublin (3rd ed.)* (Transcribed on http://www.chaptersofdublin.com/page2.html)

Keeley, B. (2004) *The Mammal Fauna of the Royal Canal.* Report prepared for Waterways Ireland and Fingal County Council.

Kelleher, C. and Marnell, F. (2006) *Bat Mitigation Guidelines for Ireland.* Irish Wildlife Manuals, No. 25. NPWS, Dublin.

King, J.J. (2007) *Ecological Assessment in relation to Atlantic Salmon in Special Areas of Conservation and potential for impact of OPW's channel maintenance work.* Central Fisheries Board, Dublin.

King, J.J. and Kelly, F.L. (2001) *A review of the ecology and distribution of three lamprey species, Lampetra fluviatilis L., Lampetra planeri (Bloch), Petromyzon marinus L.: a context for conservation and biodiversity considerations in Ireland.* Biology and Environment 101B: 165-185.

Masterson, M., Buckley, D., O'Brien, M. and Kelleher, C. (2008) *An Investigation into Bridge Usage by Bats within the Sullane & Laney River Catchments, Co. Cork.* Report prepared for The Heritage Council and National Parks and Wildlife Service.

Mitchell, F. and Ryan, M. (2007) *Reading the Irish Landscape.* Town House, Dublin. Pp. 317, 327,328

Murphy, D.F. (2004) *Requirements for the Protection of Fisheries Habitat during Construction and Development Works at River Sites.* Eastern Regional Fisheries Board, Dublin.

National Parks and Wildlife Service (NPWS) (2008) *The Status of EU Protected Habitats and Species in Ireland.* NPWS, Dublin.

National Roads Authority (NRA) (2005) *Guidelines for the Treatment of Bats During the Construction of National Road Schemes.* NRA, Dublin.

National Roads Authority (2007). *Guidelines for the Treatment of Otters Prior to the Construction of National Road Schemes.* NRA, Dublin.

Natura (2008) *Ballyboghil Bridge, County Dublin: Protected Species Survey.* Report for Fingal County Council.

O'Keeffe, P. (2001) *Ireland's Principal Roads AD. 123-1608.* National Roads Authority, Dublin.

O'Keeffe, P. (2004) *Ireland's Principal Roads AD. 1608-1898.* National Roads Authority, Dublin.

O'Keeffe, P. and Simmington, T. (1991) *Irish Stone Bridges: History and Heritage.* Irish Academic Press, Dublin.

Popplewell, L. (1987) *A Gazetteer of the Railway Contractors and Engineers of Ireland 1833-1914.* Melledgan Press, Bournemouth.

Rynne, C. (2006) *Industrial Ireland 1750-1930: An Archaeology.* Collin's Press, Cork.

Shiel, C. (1999) *Bridge use by bats in County Leitrim and County Sligo.* Report prepared for The Heritage Council. http://www.heritagecouncil.ie/publications/bats/index.html

Smiddy, P. (1991) *Bats and Bridges.* Irish Naturalist Journal 23: 425-426

Tilly, G. (2002) *Conservation of Bridges.* Spon Press, London

Appendix: Scientific names of typical species

Common Name	Scientific Name
Flora	
Alder	*Alnus glutinosa*
Annual meadow grass	*Poa annua*
Ash	*Fraxinus excelsior*
Blackthorn	*Prunus spinosa*
Bramble	*Rubus fruticosus* agg.
Broadleaved willowherb	*Epilobium montanum*
Butterfly bush	*Buddleja davidii*
Cocksfoot	*Dactylis glomerata*
Crack willow	*Salix fragilis*
Downy birch	*Betula pubescens*
Elder	*Sambucus nigra*
Fern-grass	*Catapodium rigidum*
Giant hogweed	*Heracleum mantegazzianum*
Greater water-moss	*Fontinalis antipyretica*
Hair-grass	*Aira* spp
Hart's tongue	*Phyllitis scolopendrium*
Hawthorn	*Crataegus monogyna*
Hazel	*Corylus avellana*
Herb robert	*Geranium robertianum*
Horse-chestnut	*Aesculus hippocastaneum*
Ivy	*Hedera helix*
Ivy-leaved toadflax	*Cymbalaria muralis*
Japanese knotweed	*Fallopia japonica*
Maidenhair spleenwort	*Asplenium trichomanes*
Male fern	*Dryopteris filix-mas*
Montbretia	*Crocosmia* × *crocosmiiflora*
Navelwort	*Umbellicus rupestris*
Opposite-leaved pondweed	*Groenlandia densa*

Common Name	Scientific Name
Osier	*Salix viminalis*
Pellitory-of-the-wall	*Parietaria judaica*
Polypody	*Polypodium* spp
Pondweed	*Potamogeton* spp
Purple osier	*Salix purpurea*
Red fescue	*Festuca rubra*
Red valerian	*Centranthus rubber*
Round-leaved cranesbill	*Geranium rotundifolium*
Rue-leaved saxifrage	*Saxifraga tridactylites*
Rusty-back	*Ceterach officinarum*
Rusty sally	*Salix cinerea* ssp. *oleifolia*
Shining cranesbill	*Geranium lucidum*
Stonecrops	*Sedum* spp
Sycamore	*Acer pseudoplatanus*
Thyme-leaved sandwort	*Arenaria serpyllifolia*
Wallflower	*Erysimum cheiri*
Wall-rue	*Asplenium ruta-muraria*
Water crowfoot	*Ranunulus* spp (subgenus *Batrachium*)
Water milfoil	*Myriophyllum* spp
Water starwort	*Callitriche* spp
White willow	*Salix alba*
Yorkshire fog	*Holcus lanatus*
Mammals	
Badger	*Meles meles*
Brown long-eared bat	*Plecotus auritus*
Brown rat	*Ratus norvegica*
Common pipistrelle	*Pipistrellus pipistrellus*
Daubenton's bat	*Myostis daubentonii*
Fox	*Vulpes vulpes*
House mouse	*Mus musculus*
Irish hare	*Lepus timidus hibernicus*
Natterer's bat	*Myostis nattereri*

Common Name	Scientific Name
Otter	*Lutra lutra*
Pygmy shrew	*Sorex minutus*
Soprano pipistrelle	*Pipistrellus pygmaeus*
Whiskered bat	*Myostis mystacinus*
Wood mouse	*Apodemus sylvatica*
Birds	
Blackbird	*Turdus merula*
Blue Tit	*Parus caeruleus*
Coal Tit	*Parus ater*
Dipper	*Cinclus cinclus*
Grey Heron	*Ardea cinerea*
Grey Wagtail	*Motacilla cinerea*
House Martin	*Delichon urbica*
Little Egret	*Egretta garzetta*
Long-Tailed Tit	*Aegithalos caudatus*
Moorhen	*Gallinula chloropus*
Pheasant	*Phasianus colchicus*
Pied Wagtail	*Motacilla alba*
Robin	*Erithacus rubecula*
Song Thrush	*Turdus philomelos*
Swallow	*Hirundo rustica*
Wren	*Troglodytes troglodytes*
Aquatic fauna	
Atlantic Salmon	*Salmo salar*
Blue-tailed damselfly	*Ichnura elegans*
Brook Lamprey	*Lampetra planeri*
Brown hawker	*Aeshna grandis*
Common blue damselfly	*Calopteryx splendens*
Common darter	*Sympetrum striolatum*
Hairy dragonfly	*Brachytron pratense*
River Lamprey	*Lampetra fluviatilis*
Sea Lamprey	*Petromyzon marinus*

Common Name	Scientific Name
Trout	*Salmo trutta*
White-clawed crayfish	*Austropotamobius pallipes*