IMPACTS OF CLIMATE CHANGE
ON THE HISTORIC BUILT ENVIRONMENT:

A REPORT & GUIDE

ULSTER ARCHITECTURAL HERITAGE

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FOREWORD:

Few now doubt the existence of global warming and the resultant climate change. We regularly see the impact of this across the world on our TV screens and increasingly experience it locally. More and more it is clear that climate change will affect every aspect of our lives.

This timely report and guide outlines the climate change and the related risks which could threaten the survival and long term sustainability of Northern Ireland's historic built environment. Strategies are proposed to assess, monitor, adapt and mitigate against current and developing impacts.

Huge thanks are due to all those involved in the production of this report comprising former UAH Chief Executive Ms. Nikki McVeigh, the main author, who was assisted by other key contributors including UAH Vice Chair and Chair of Architecture, Planning & Policy, Mr John Anderson, UAH Committee Members Dr Patricia Warke , Dr Marcus Patton OBE, and UAH Heritage Projects Officer, Dr Connie Gerrow.

Climate change is an evolving challenge that requires immediate action. This report is published in the wake of the Covid-19 pandemic which has presented a sudden global challenge of epic proportions and in the year of the COP 26 conference in Glasgow. It will be a bookmark in history, something that will punctuate memory. While such events have a terrible human cost, as we go forward we must not only learn from them, but also ensure that new knowledge or understanding is harnessed for good. The Second World War, after all, necessitated the mass production of penicillin.

As I reflect on the COVID-19 pandemic I believe that we have all relearned something of the humility of our forefathers and a renewed respect for nature in all its forms. We have all become much more aware that, as John Donne famously wrote almost 400 years ago, "no man is an island". We each have our part to play for the good of the whole community and indeed the planet. The pandemic has been a wake-up call to the reality of global emergencies and we must now direct similar focus on climate change and its impact with the same candour, urgency and energy. This valuable report is an important tool as we address the impact of climate change on our historic built environment and in turn make the most of the significant positive contribution that this asset can offer, both in terms of carbon savings, and through the sustainable provision of much needed housing.

David J Johnston OBE
Chair, Ulster Architectural Heritage

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Introduction:

This report and guide outlines the climate change and associated risks which may threaten the survival and long term sustainability of Northern Ireland's historic built environment. Strategies are proposed to assess, monitor, adapt and mitigate against current and developing impacts. The report highlights the need for building owners and custodians to understand the areas of vulnerability of their assets and then to focus attention on what additional adverse impacts might come into play as a consequence of radically changing meteorological patterns and events - a changing climate.

The report aims to alert owners and custodians, of both modest and nationally important historic buildings, that they will inevitably face additional responsibility and a more frequent need to care for their buildings. This will become increasingly important as climate change continues on the present trajectory in line with predictions. However, this report and guide emphasises that dealing with the impacts of climate change will often be a case of lower cost measures through enhancing routine monitoring, maintenance and repair; with appropriate adaptation or mitigation measures required only in the more at risk cases. A small number of cases will need costly, challenging and technically complex intervention in the face of flooding, erosion, or subsidence threat.

Northern Ireland's historic environment is a finite, fragile and non-renewable asset which showcases our unique historical, cultural and physical identity, and promotes our pride of place. The historic environment is internationally accepted as key to sustainable income generation and tourism. Northern Ireland is fortunate in having a wealth of historic assets contained within a compact geographic area which spans across a broad range of styles, functions and periods; with considerable untapped potential to deliver tangible economic, cultural and social benefits. It is an obvious imperative that Northern Ireland must make best efforts to protect its historic built environment in order to sustainably profit from it into the future.

For the purposes of this guide and report, the term 'historic built environment' refers to any historic building constructed before 1919. This does not only include stately homes, but also domestic properties of any scale, religious buildings, scheduled monuments, industrial buildings and infrastructure. Please note, other parties may define this term differently.

It is now widely accepted - our climate is changing. According to the UK Climate Projections (UKCP18), *'even given strenuous efforts to limit the cause of global warming, further climatic changes are inevitable in the future and the UK will need to manage the growing risks from climate change'*[1]. A growing, worldwide promotion of actions for climate response reflects the potential magnitude of the issue of climate change; and its potential longer-term impact across society. The Climate Change Act

[1] Met Office Hadley Centre (2019), p2

2008 establishes a legally–binding framework for the UK Government to address and combat climate change. The Paris Agreement, 2016, followed with a goal to limit global warming and to reach global peaking of greenhouse gas emissions as soon as possible, to achieve a climate neutral world by mid-century.
In addition to this, the UN Member States have established Sustainable Development Goals. This is a strategic and universal call to action to end poverty, protect the planet and improve the lives and prospects of everyone, everywhere. The 17 Goals were adopted by all UN Member States in 2015, as part of the 2030 Agenda for Sustainable Development which set out a 15-year plan to achieve these Goals. Specifically, With Sustainable Development Goal 11, Sustainable Cities & Communities, countries have pledged to *'make cities and human settlements inclusive, safe, resilient and sustainable'*[2]. Within this goal, Target 11.4 aims to *'strengthen efforts to protect and safeguard the world's cultural and natural heritage.'*[3]

A Climate Change Bill for Northern Ireland was first officially proposed in March 2021, to put in place the necessary powers to enable the mitigation of the impact of climate change in Northern Ireland, to establish a legally binding net-zero carbon target[4].

Marcus Patton OBE, Chair of the Historic Buildings Council for Northern Ireland 2017-20, and current Committee Member of Ulster Architectural Heritage summarised his view on climate change and the historic built environment as follows:

"*In Northern Ireland, we need to make much better use of what we have got in our existing buildings, adapting or improving them before replacing them. There are lessons to be learned from old buildings - the flexibility and breathability of lime, the reparability of timber, the healthiness of ventilation, the advantages of thermal mass, the common-sense of terraces and tenements, the sociability of streets. We also need to think about how we live in historic buildings, day to day with regard to best responding to climate change."* See full statement, page 7.

- **How does climate change, and the associated NI, UK and UN commitments, link to the historic built environment?**

It is important to acknowledge, there are 2 primary but markedly different headline topics relating to climate change and the historic built environment. These include:

1.1 Topic 1 - The impact of climate change on the historic built environment.

Northern Ireland's historic buildings, sites and landscapes have already experienced and survived often hundreds of years of climatic changes, and have therefore proven durability. By way of their design, construction, and upkeep through maintenance and repair, a historic structure may in fact present good resilience in the face of future climate change. However, climate change places additional, and inevitably some unforeseen strains on historic buildings, sites and monuments. These upcoming physical challenges posed by climate change are significant and must be understood and managed going forward to assure and maximise the positive impact the historic environment contributes to combating the effects of climate change.

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[2] United Nations (2015), p14
[3] Ibid. p22
[4] Northern Ireland Assembly (2021a)

See Topic 2, section 1.2.

1.2 Topic 2 - The impact of the historic built environment on level of carbon emissions and climate change.

The built environment and construction constitutes over 40% of the UK's carbon footprint.[5] When considering climate change mitigation in the context of the potential contribution of Northern Ireland's historic built environment, several factors are important: Long term habitation and usage, the conserving of the embodied energy which spans the life of buildings from construction through often centuries of sustained use, and, the positive impact of heritage led regeneration and appropriate retrofit.

- **Do Historic Buildings have a role in addressing climate change?**

Historic buildings can help to mitigate the effects of climate change through the prioritisation of their use or re-use as an alternative to new-builds. By so doing, the emissions generated by all of the processes associated with the production of a new building, from the mining and processing of natural resources through product manufacturing, transport and delivery, will be substantially reduced. Furthermore, embodied carbon in existing buildings would not be lost through demolition.[6]

- **Can energy improvements in the use and reuse of Historic Buildings help to address climate change?**

Within the case for sustained use of historic buildings to reduce carbon emissions is the additional objective to save energy through practices of maintenance, management and, where appropriate, retrofit for energy efficiency. This will not generally apply to monuments and archaeological sites, most of which are likely to be carbon neutral.

The UK Climate Change Committee outlines that '*decarbonising and adapting the UK's housing stock is critical for meeting legally-binding emissions targets by 2050 and preparing for the impacts of climate change*'[7]. Historic England also asserts that the sensitive refurbishment and adaptation of historic buildings with improved energy efficiency measures would be instrumental in reaching 2050 carbon targets; with the possibility of reducing carbon emissions by up to 39.6 million tonnes by 2050, should all pre-1919 residential buildings be responsibly refurbished over the course of the next ten years.[8] However, it is acknowledged that more research is needed to identify and quantify the opportunities for reuse of heritage assets[9] - findings of such research are likely to be of relevance to Northern Ireland, as the type and efficiency of its housing stock is similar to that of the rest of the UK[10].

In 2019, the UK Climate Change Committee made recommendations for Northern Ireland to support energy efficiency improvements in existing buildings, and to legislate

[5] UKGBC (ND)
[6] Historic England (2020)
[7] UK Climate Change Committee (2019a)
[8] Historic England (2020)
[9] Ibid.
[10] UK Climate Change Committee (2019b), p70

energy efficiency targets.[11] As of March 2021, refurbishment of existing buildings is being considered as part of Northern Ireland government policy to achieve 'net zero'[12], however a programme of refurbishment, related incentives, and how such a programme might relate to historic buildings has yet to be announced.

While there is a clear opportunity to improve the energy efficiency of our existing building stock, it is very important to always ensure that best practice historic building maintenance and retrofit is adopted to avoid any unintended consequences arising from inappropriate works. A number of useful case-studies are available via the Historic Environment Scotland website, which discuss the in-situ performance of retrofit measures of varying cost and invasiveness.[13]

Not all works to improve energy efficiency in modern buildings are suitable for historic buildings, due to the differences in the way that traditional/historic construction, materials and design interact with the local climate. A historic building benefits from its own, perhaps long-established, cycle of heat, ventilation, airflow, wetting and drying. Inappropriate maintenance and retrofit measures may not only do harm to a building's character, but also disturb a building's equilibrium, thus serving to do more harm to historic structures than good. It is also important that incorrect assumptions are not made as to the energy performance of historic materials when considering retrofit measures. Research undertaken by SPAB suggests that the actual thermal performance of solid walls was underestimated in 77% of sampled cases; which could lead to disproportionate and invasive measures being undertaken unnecessarily.[14]

Speaking about the Historic Built Environment and Climate Change, Dr Marcus Patton OBE, former Chairman of the Historic Buildings Council (HBC) Northern Ireland outlined the following summary:

It doesn't seem many years since scientists were debating, if not whether climate was changing, certainly how fast it was changing and what was causing the change. But in a few short years the evidence, corroborated by the Australian bushfires and the death of half a billion animals there last year, followed by heatwaves this year, has become virtually undeniable.

When the MPs at Westminster declared a climate emergency-and stated that the UK would be carbon neutral by 2050, they probably thought they could carry on more or less as normal for a few more years, recycling plastic bags and taking some of their journeys by train instead of 4x4 or plane. Few politicians now deny climate change - but probably not many have worked out what has happened and what we have to do next. Lockdown seemed to demonstrate how we could manage without cars and planes, meeting by zoom instead of having every meeting in person. There was hope that in coming out of lockdown industry would be greener. On the contrary, the economic recovery seems to have been accompanied by a rapid growth in greenhouse gases.

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[11] Ibid., p85
[12] Northern Ireland Assembly (2021b), pp39, 43
[13] Historic Environment Scotland (ND)
[14] SPAB (ND)

Architects have been talking about zero-carbon passive houses and retrofitting for a decade or so, secure in the knowledge that this means more work for architects, but there is a growing realisation that "sustainable development" may not actually be sustainable. Greta Thunberg put her finger on it in her clear-headed way. You can't be a little bit sustainable, she pointed out - either you are sustainable, or you're not sustainable. Actually, almost any form of development or commerce consumes energy or uses materials or creates pollution.

And the building industry is one of the most damaging aspects of Western civilisation, being responsible for almost all the world's concrete production, half of the steel and a quarter of the plastic. In the UK, 63% of our waste comes from construction and demolition. Yes, a badly insulated house will waste heat unnecessarily, but half the whole-life carbon cost of a new house has already been generated by simply building it, and with the "economic life" of a new house being taken at sixty years many buildings are being demolished when the construction cost is an even higher percentage.

While global warming has been going on for most of the 20th century, the big changes happened after about 1970 and the biggest ones have been in the last ten years. What has changed at those trigger points? For a start, the world's population in 1927 was 2,000m; it had reached 3,700m by 1970 and has more than doubled that to 7,800m today. And every one of those people wants clothing, housing and energy. And on a local scale, in 1970 only 30% of British houses had central heating, but now it is over 95% - and over that period the average temperature in British houses has risen by over 5°C. So there are many more of us, and we are each consuming more- in some cases much more - than even our recent ancestors.

Tempting as it is to build our way out of climate change by making more efficient houses, the fact is that building them costs energy and requires transport and the manufacture or extraction of materials, creating pollution and climate-changing gases, destroying wildlife habitats and sometimes depleting rare resources. We need to make much better use of what we have got in our existing buildings, adapting or improving them before replacing them. There are lessons to be learned from old buildings - the flexibility and breathability of lime, the repairability of timber, the healthiness of ventilation, the advantages of thermal mass, the common-sense of terraces and tenements, the sociability of streets. We also need to think about how we live in them.

Why do we over-heat our buildings while dressing ourselves for the summer in winter? Adequately fit and nourished human beings, if suitably clad, sustainably heat themselves, and surely this is sensible rather than burning additional fossil fuels by just turning up the central heating without a second thought, (or worse still, the air conditioning)?

In short, we need to reduce consumption, to re-use and repair what we have. Government has to scrap the VAT exemption for new construction and re-introduce incentives for sustainable re-use of our historic building stock.

We will of course have to build some new structures, and they will have to be very efficient, but above all they will have to be durable so that they have a long life, *adaptable so that they can be used for many generations, and beautiful so that people want to keep them.*[15]

1.3 This Report and Guide

This report focuses on topic 1, section 1.1 - The impact of climate change on the historic built environment, i.e. pre-1919 historic buildings and upstanding monuments in Northern Ireland.

Topic 2, section 1.2 - *the potential positive impact that the historic built environment can have on mitigating the effect of climate change via reduction of carbon emissions* – is significant and should be a priority in the Northern Ireland strategic response to climate change. To maintain, sustain and respect our historic built environment requires strategic appreciation of both its sustainable cultural and economic value but also the ability to both enhance the environment of the present and additionally serve the needs of the future for society through climate change mitigation.

Underpinning all of this is the fact that existing buildings that are in current use or have potential for use, are already mitigating against the carbon emissions which are inherent in the prevailing Northern Ireland culture of demolition and new build.

The purpose of this report and guide is to outline the risks which climate change poses to the survival and long-term sustainability of Northern Ireland's historic built environment, and propose strategies to assess, monitor, adapt and mitigate against current and developing impacts. The evidence included in this report summarises the actions which owners, custodians, funders and legislative and government bodies should take in the face of a changing climate. The report will highlight the need for owners and custodians to understand the areas of vulnerability of their assets, to identify specific risks and develop and adopt measures to render their historic buildings resilient in the face of climate change.

This report and guide does not seek to argue the scientific case for proof of global warming and related climate change; but rather that, in the face of almost universally accepted scientific evidence, the precautionary principle should be adopted by assessing risk and preparing options to address the impact of climate change on our historic buildings. This includes predicted extreme weather events, changes to long standing weather patterns, and the associated risks engendered as a consequence.

[15] Extract from an article posted on the UAH website on 1 November 2021 to coincide with the COP26 summit in Glasgow see: www.ulsterachitecturalheritae.org.uk/news/cop26/

BACKGROUND

Northern Ireland has always experienced periods of severe weather, and our buildings have traditionally been well built to withstand challenging climate conditions; including precipitation, wind, temperature, storms, or extremes that include a number of climate factors at once. If well maintained, and not detrimentally altered, our historic buildings have demonstrated that they can withstand the meteorological conditions that prevail in Northern Ireland, sometimes rather better than more recent builds. However, it is now widely acknowledged that climate change is changing our weather patterns. Environmental stresses and strains that impact on buildings are seen to have altered and increased. Buildings that have typically withstood these meteorological conditions are, in some cases, now less able to cope. Therefore, on top of routine maintenance and repair of buildings, comes the added challenge for owners of managing accelerated climate change impacts.

The projections show that in the absence of a significant reduction in carbon emissions, the meteorological and environmental conditions within which an historic building has to cope has been, and will be, progressively altered over the coming years; posing increased and/or new challenges in the ways we must care for and conserve the historic built environment. This report considers the background to climate change and its effects on the historic built environment of the UK and Northern Ireland. Based on this review, the report establishes a risk assessment process; acknowledging that impacts of climate change on a particular heritage asset will be affected through contextual, material and building and site specific factors. Based on the risk assessment, this report summarises different approaches to climate change threat that can be applied to historic buildings and upstanding monuments, referencing key examples.

2.1 Climate in the UK and Northern Ireland

In advance of going into the detail of climate *change*, it is important to consider an overview of Northern Ireland's inherent weather conditions versus climate - the weather conditions prevailing in an area in general or over a long period. The standard weather patterns that represent the climate of Northern Ireland are those that have impacted the historic built environment for centuries, and are those that are now **changing** as a result of climate change.

The climate of Northern Ireland owes much to its mid-latitude oceanic position, with heat transfers from the relatively warm surface waters of the North Atlantic Drift; to the overlying atmosphere enhancing maritime influences. These have a significant moderating influence on the Northern Ireland climate, given what might otherwise be expected at our latitude. The prevailing direction of rain-bearing weather is from the

South West, and is dominated by low pressure systems that track in from across the North Atlantic.[16]

Northern Ireland's oceanic climate regime means that temperature extremes are rare, and mean air temperature fluctuates within narrow limits. At low altitudes, mean annual temperatures range from 8.5°C to 9.5°C, with the higher values occurring in coastal areas. Mean annual temperature decreases by approximately 0.5°C per 100 metres rise above sea level.[17] Away from the moderating influence of coastal waters, temperature ranges in summer and winter can be more extreme, with colder conditions during winter months and higher summer temperatures.

Average daily maximum temperatures in February range from about 7°C at coastal sites, to around 5°C over the upland areas. Along the coasts, mean minimum temperature is 2.5°C, decreasing inland to less than 0°C over upland summits. July is normally the warmest month, with mean daily maximum temperatures between 18°C and 19°C inland at low altitude, 17°C to 18°C along coasts and less than 17°C over uplands.[18]

Predominant wind directions are between 200°–280° (approximately SSW to WNW), although surface airflow is greatly modified by topography and large scale meteorological conditions. The close proximity of Northern Ireland to depression tracks over the Atlantic results in stronger winds than experienced by other parts of the British Isles; although western Scotland, the extreme south-east of England, and the south-western approaches can be exposed to storm force winds. Mean annual wind speed ranges from in excess of 6.7 m s^{-1} on the North Antrim coast to less than 4.1 m s^{-1} at sheltered inland sites with maximum velocities typically occurring between November and March.[19]

There is a clear rainfall gradient across Northern Ireland with higher rainfall in the west and lower amounts of rainfall in the east. Higher rainfall amounts associated with upland areas such as the Mourne Mountains and the Antrim Plateau disrupt this pattern, and these different baseline conditions of location and topography have implications for the impact of projected climate change across the Province.

2.2 Climate Change in the UK and Northern Ireland

Analysis of the ways in which the UK Climate is likely to change are presented in the UK Climate Change Projections, 2018, (UKCP18). This initiative by the MET Office sets out projected or likely scenarios that the climate may present up to 2100 and beyond. General climate change trends projected over UK land for the 21st century are broadly consistent with earlier projections (UKCP09), with the key changes identified below:

- **Increased summer and winter temperatures;**
- **Increased winter precipitation;**
- **Decreased summer precipitation;**

[16] Betts, N.L. (1997), pp63-84
[17] Ibid.
[18] Ibid.
[19] Ibid.

- **Increased number of heavy rainfall events (>25mm/day) for summer and winter and therefore risk of flooding;**
- **Sea-level rise;**
- **Longer growing season;**
- **Increase in the frequency and intensity of extremes e.g. storms;**
- **Increased likelihood of compounded extreme weather events.**

There are general trends indicating a shift towards warmer wetter winters and drier hotter summers, but with more instances of what were formerly regarded as 1 in 100 or 1 in 50 year ‘extreme’, and/or, unseasonal (for NI) events. These could include episodes of persistent heavy driven rain, storm force winds, storm surge flooding along coasts, and periods of drought. At times, extreme weather events do not occur in isolation but can be ‘compounded’ with several events occurring in succession, for example, a series of storm systems.

2.3 Historic built environment in Northern Ireland

This report and guide considers the historic built environment in the context of climate and climate change. Northern Ireland’s pre-1919 historic built environment includes a wide range of assets. These include smaller scale urban and rural housing, industrial buildings and the ‘grander’ buildings, such as churches, commercial and municipal buildings and the ‘big houses’. Such assets may be of individual significance, and/or be integral to the character of historic villages, towns, demesnes, parks and gardens. Additionally, the historic built environment includes archaeological sites and monuments, and marine archaeology which may be subject to very different contextual and material conditions than those of a maintained building. Examples of these include industrial and military heritage assets, bridges, harbours, docks, etc. The most common way of categorising different aspects of the historic built environment in Northern Ireland is by designation:

- **Historic Buildings (Listed only);**
- **Conservation Areas**
- **Areas of Townscape Character**
- **Historic Parks, Gardens and Demesnes**
- **Industrial Heritage**
- **Scheduled Monuments**
- **Defence Heritage**

Unlisted buildings or individual entries on the Sites and Monuments Record are not formally designated sites, but they may have some form of protection through planning policy. For example, the policy on archaeological sites (BH2) or the policy on unlisted vernacular buildings (BH 15).

There are approximately 8,900 listed buildings, 66 conservation areas, 177 Areas of Townscape Character and 32 Areas of Village Character in Northern Ireland.

Legislation for the protection of historic buildings and associated governance responsibility now lies between the 11 local authorities, Department for Communities: Historic Environment Division (HED) and Department for Infrastructure: Planning NI.

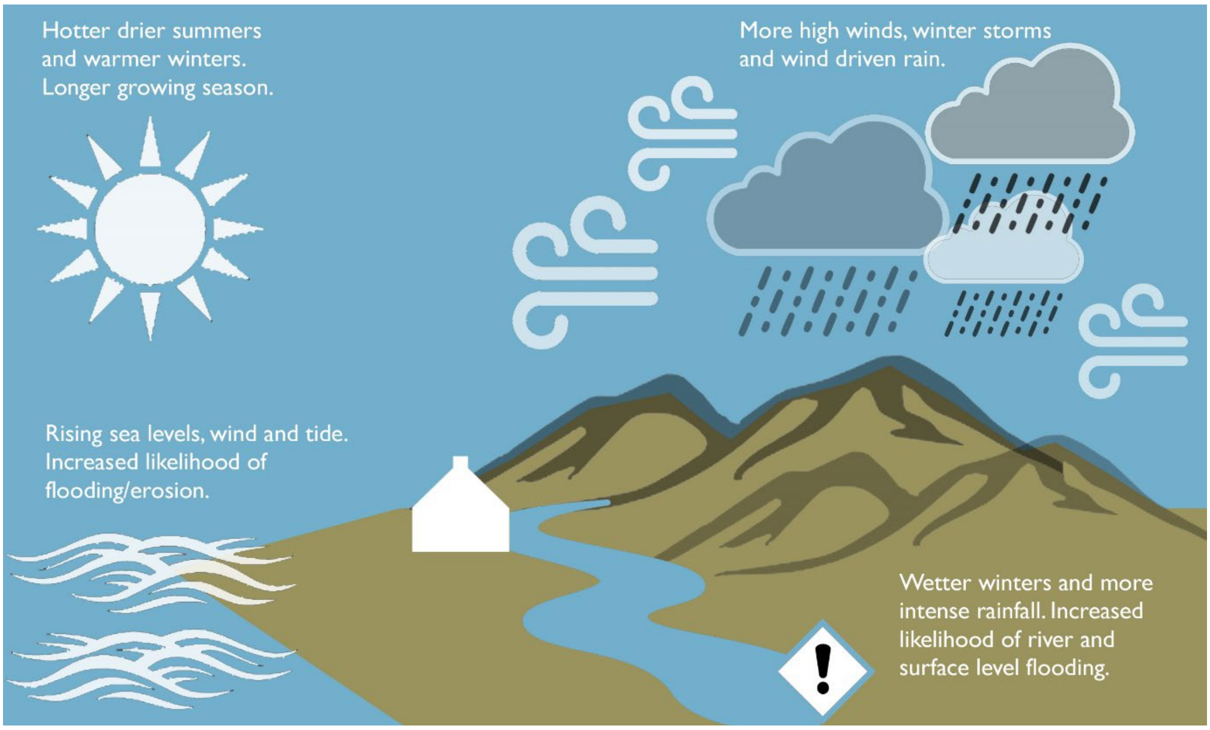
Since 2015, a large part of the responsibility and control for protection of the local historic built environment lies with local authorities. This encompasses planning, including designation of conservation areas, enforcement, building preservation notices, repairs notices, urgent works notices, local listing, and community and local development planning.

IMPACT OF CLIMATE CHANGE ON THE HISTORIC BUILT ENVIRONMENT- AN OVERVIEW

Weather conditions have always created challenges for built structures but climate change has been associated with an increase in the magnitude (impact) and frequency of extreme weather events. This presents challenges for all structures but particularly for historic buildings and monuments; and has considerable implications for their upkeep, maintenance and long-term protection.

In addition to the 'normal' environmental stresses that historic structures are exposed to on a daily basis, described here as high frequency, low magnitude (impact) events, they are having to resolve the stresses arising from more extreme events described here as low frequency, high magnitude (impact) events. The ability of a historic structure to resolve these stresses can be supported by good management and maintenance programmes.

FIGURE 1. POTENTIAL IMPACT OF CLIMATE CHANGE ON WEATHER EVENTS, AFFECTING THE HISTORIC ENVIRONMENT. ***BASED ON HES, FIG.3; PG.7; HISTORIC ENVIRONMENT SCOTLAND, CLIMATE CHANGE ADAPTATION FOR TRADITIONAL BUILDINGS, CURTIS AND SNOW, 2016. ADAPTED BY UAH FOR THE PURPOSES OF THIS REPORT.***



3.1 HIGH FREQUENCY LOW IMPACT EVENTS THAT MAY BE AFFECTED BY CLIMATE CHANGE

The fabric of a building is subject to daily stresses, for example heating and cooling and wetting and drying. These stresses have a low impact on the resilience of building materials on a daily basis, but over time they contribute to the 'aging' of the materials and a decrease in resilience.
As climate change is reflected in increased rainfall during winter months, this may increase pressure on the capacity of rainwater goods and increase the potential for water penetration into the fabric of buildings (masonry components); particularly as there is less opportunity for drying between rainfall events – conditions that may be conducive to the growth of algae and moss on masonry surfaces and mould growth in adjacent timbers. In addition to this, buildings may be exposed to increased thermal stress during hotter drier summers – conditions that can also lead to subsidence, as ground-fill shrinks as it dries.

3.2 LOW FREQUENCY HIGH IMPACT EVENTS THAT MAY BE AFFECTED BY CLIMATE CHANGE

Unlike high frequency, low impact events, the low frequency, high impact events can result in immediate and obvious damage to the fabric of a building. In NI, these are typically associated with storms and flooding arising from periods of intense rainfall and/or coastal tidal surges. The frequency of such events are projected to increase throughout the 21st Century with potentially significant implications for historic structures. For example, flooding may occur in areas with no history of flooding, thereby exposing structures to damage from water ingress and contamination. Alternatively, the frequency of flooding may increase in areas where flooding has occasionally occurred in the past and result in structural damage.

A greater frequency of storms with high wind speeds and driven rain may damage the fabric of historic structures with, for example, damage or loss of slates and overwhelming of rainwater goods. The significance of these extreme events is that they place a short-term stress burden on a historic structure and greatly increase the chance of damage – this underlines the importance of careful checking of the external components of the building fabric following a storm.

By being aware of the frequency and associated potential impacts of these stresses on historic materials it can allow us to better understand what, if any, risk a historic building or structure may be exposed to as a result of changing climate. This can allow us to, where possible, put in measures for monitoring and management; and where necessary, advance emergency response planning, for example, where a building is vulnerable to flooding.

Key Factors Affecting Impacts of Climate Change on the Historic Built Environment

It is acknowledged that climate change and the associated variances to historic meteorological and environmental trends in wind, rain, temperature, etc., will likely impact the historic built environment. However, the relative degree to which any particular structure may be impacted in Northern Ireland will depend - not only on the ways in which the climate is changing here - but also **other** contextual and physical factors upon which the pressure of changing climate is being applied.

The impact or likely risk to a heritage asset, such as a historic building, a monument or an area of archaeological significance is dependent on a variety of factors. In summary, these include:

To assess the likely impact of climate change on any particular historic asset, an owner may consider their asset against each factor, and consider whether it may be important to take measures to best protect it from the likely effects of climate change, now and in the future.

Risk Assessment

In the assessment of current or likely impacts which climate change may have on a particular historic building or monument, it is important to get to know the building and structure:

1. **Of primary importance is that owners must consider inherent factors that may affect the resilience of the building - in particular the type of building, its construction and fabric, and its site;**

2. **Assess the current condition of the building or monument, and the procedures in place for maintenance and monitoring;**

3. **Apply the risk assessment and use the results to shape actions to protect and mediate against climate change, according to statutory controls where applicable.**

For instance, it may be that primary construction materials or particular locations are susceptible in particular ways to increased stresses of climate change. It may be that issues around condition, level of maintenance or monitoring, are in fact exacerbating the effect that climate change is having on a particular structure; whereby two of these factors may be working synergistically to result in historic fabric becoming less resilient to the changes in climate conditions and time of exposure. It should be remembered that the impact of climate change will vary from asset to asset, and should be assessed on individual basis.

5.1 TYPE

When considering the likely impact of climate change on heritage assets, it is helpful to categorise the ‘type’ of a heritage asset, by designation or otherwise. This, by definition, may give an idea of a heritage asset’s general physicality and characteristics. For instance, potential challenges of climate change may be different in a conservation area, an implied concentration of heritage assets; rather than to those faced by a single building, or indeed a monument. A historic park or garden may present different physical contexts, and designed landscapes, presenting a wider range of assets that may need to be considered. Different designations may also imply different levels of occupancy and of implied management, and monitoring requirements. Key headline designations, and datasets for information relating to the historic built environment include:

- **Historic Buildings (listed/unlisted/record only)**
- **Conservation Areas**
- **Areas of Townscape Character**
- **Historic Parks, Gardens and Demesnes**
- **Industrial Heritage**
- **Sites and Monuments**
- **Scheduled Historic Monuments/Zones**
- **Defence Heritage**
- **Heritage at Risk**

The title designation, or closest comparator, will provide reference to legislative controls. In some instances, records may include in-depth information on the building(s) or monument(s). The title designation will also directly relate to its significance, existing legislative context, records and datasets.

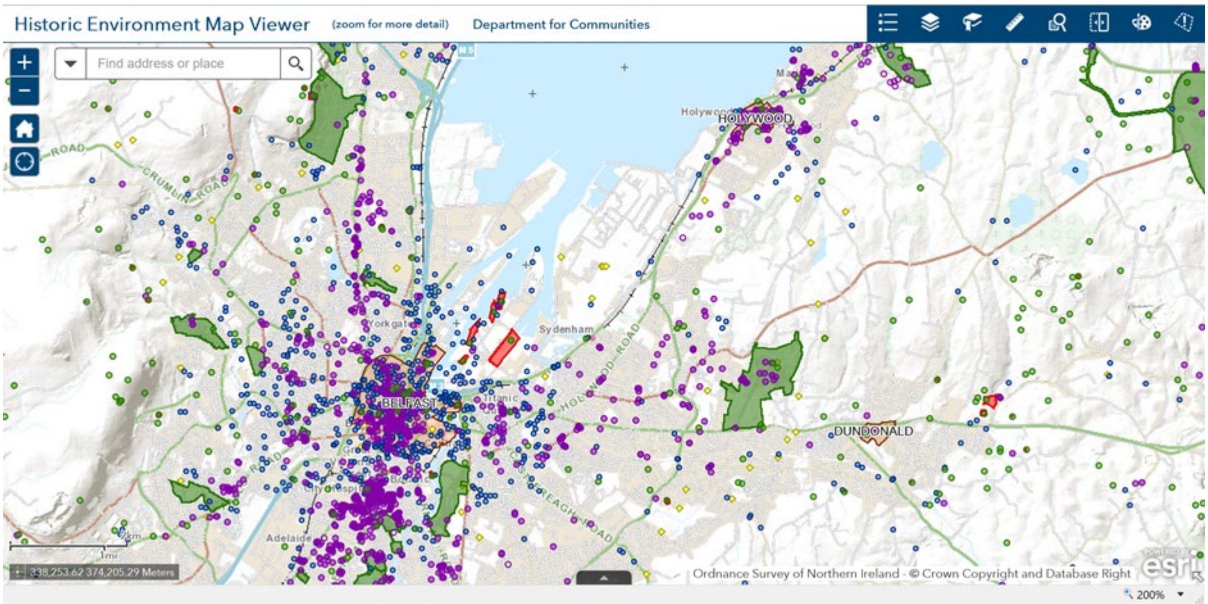
It is acknowledged that not all heritage assets may be protected by designation, in which case we might assess against the closest comparator. If designated, it is likely an asset will have statutory protection, as for example a listed building or a scheduled monument; in which case, advice and approvals (where applicable) should be sought. Where consents are required, if works to address the impacts of climate change involve detail or structural alterations, rather than ‘like for like’ repairs, it is advised to make contact in advance with the relevant local authority and the DfC Historic Environment Division (HED).

To identify type, find out more about the relative importance of an asset, and any designations, an owner may consult records of heritage assets with the Department for Communities: Historic Environment Division. A good, accessible way of doing this is through the Historic Environment Map Viewer, which provides a range of datasets, historical maps and contemporary maps. Each of these are displayed on the map as a ‘layer’, linking to the Department for Communities Buildings Database, where you may source more information on the architectural and historical significance of a building:

- Historic Environment Map Viewer: https://www.communities-ni.gov.uk/services/historic-environment-map-viewer

- Buildings Database:
  https://www.communities-ni.gov.uk/services/buildings-database

FIGURE 2. HISTORIC ENVIRONMENT MAP VIEWER



RISK ASSESSMENT STAGE 1: TYPE

What type of heritage asset is it?

- **Historic Buildings (listed/unlisted/record only)**
- **Conservation Areas**
- **Areas of Townscape Character**
- **Historic Parks, Gardens and Demesnes**
- **Industrial Heritage**
- **Sites and Monuments**
- **Scheduled Monuments/ Zones/ Monuments in State Care**
- **Defence Heritage**

Is the asset protected by a designation? If so, which? Refer to the relevant legislation, seek advice, and where applicable consent before any works are carried out.

5.2 SITE

In addition to the aforementioned TYPE, (the general character of the asset), the likely impact of climate change on a heritage asset will be dependent on Site (where a particular building is physically sited), and an analysis of the systems and processes involved in the weather, mountains, seas, lakes, etc. that impact upon it. There is also the opportunity to analyse the ways in which we have sought to inhabit Northern Ireland, and site buildings relative to various factors. Different locations will be affected by differing environmental considerations, such as being elevated or sheltered, vulnerable to coastal, river or surface water flooding, or erosion, subsidence, etc.

Rainfall, and the impact of meteorological conditions, particularly extremes, such as flooding or storm damage, may be heightened or reduced according to location and the direction of repeated and compounded extreme weather events. Historic buildings situated on the coast or in proximity to the sea may also experience additional challenges, as they will be more greatly exposed to weather events and the salty environment.

There may be an increasing risk of coastal flooding from storm surges; and in some areas, land and buildings may be under threat from coastal erosion and sea level rise. With higher levels of precipitation, and extremes, there is also a higher risk of river flooding and localised surface water flooding. Key factors to consider with regard to locality include: **location, topography, flooding and erosion.**

It is important to note the relevance of Geographical Information Systems (GIS) as a potential key instrument in the management of Heritage and Climate Change. The geolocation (the identification of a place via an electronic device) of an asset is important to assess the risks inherent in its location (a point in physical space) and can also be used to identify trends across different assets or locations.

Typically, GIS allows the user to layer different data together; for instance, the geolocation of an asset or group of assets against the available rainfall, flood risk (rivers, sea and surface water) and erosion data, which will be discussed below. At present, a map employing all these datasets is not available for Northern Ireland. This may change in the future, but in the meantime, the data is readily accessible for each topic online. One example of the use of geolocation and GIS system for assessing risk is the Department for Infrastructure: Flood Maps NI[20], which will be discussed in further detail in the next section.
In 2020 the National Trust has developed a 'climate hazards' map on GIS that seeks to illustrate the threat that climate change poses to the places the National Trust cares for, and pinpoint locations that may need intervention:

[20] www.nidirect.gov.uk/articles/check-the-risk-of-flooding-in-your-area

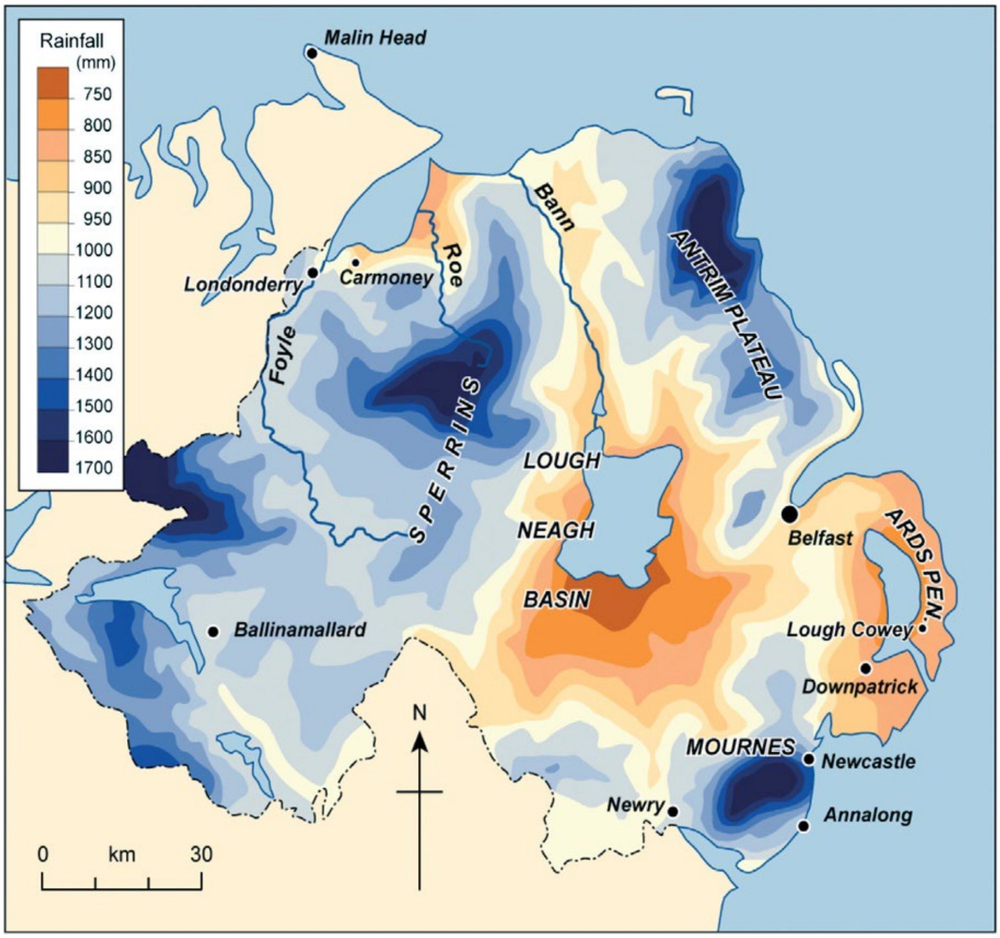
- National Trust Climate Hazard Map: https://nationaltrust.maps.arcgis.com/apps/webappviewer/index.html?id=0bc569747210413a8c8598535a6b36e1

1.2.1 Location

Where a building is located is very important, as there is a general west-east trend of decreasing precipitation. Seasonal variation of precipitation in Northern Ireland is not large, but the wettest months occur between August and January. Away from the lowlands, particularly in the west, a winter precipitation maximum is more pronounced, associated with the most intense depressions at this season. Upland stations have in excess of 10mm in each month between August and January, and some sites, particularly in the west, experience this amount in all months. 'Wet days' (daily precipitation ≥1mm) range from 150 days in the east to 200 days in the west and uplands.[21]

Therefore, it may be considered that those heritage assets in the West of Northern Ireland generally experience a higher level of exposure, over longer periods of time than those in the East.

FIGURE 3. MEAN ANNUAL PRECIPITATION (MM) FOR NORTHERN IRELAND (NIR), 1961–1990 (AFTER BETTS 2002)



[21] See Betts (1997), pp63-84, and Betts (2002), pp26-42

1.2.2 TOPOGRAPHY

With regard to location, topography or elevation may also be a factor for the impacts of climate change.

The general west-east trend of decreasing precipitation is complicated by topography. Highest areas of upland receive annual precipitation in excess of 1600mm. In contrast, parts of the Ards peninsula receive less than 800mm and the driest areas are the upper Bann - Lough Neagh lowlands with annual totals less than 750mm annually, (Figure 3).

With this in mind, the topographical location of a building may need to be considered alongside the general west-east trend of decreasing rainfall when looking at the environmental challenges a particular asset is facing; and what impact this may have now and in the future with the consideration climate change in mind. How the topographical location relates to elevation of an asset may also mean higher or lower risk of flooding.

1.2.3 FLOODING

Rainfall and topography, outlined above, may be contributory to assessing whether or not a heritage asset is at risk from flooding; and whether an asset may have an increased chance of flooding in the future context of climate change. This will depend largely on the proximity of a building to the coast, rivers, and surface water, e.g. run off from high ground and hard surfacing. This may also depend on the provision and functionality of infrastructure, for example drainage, both in the immediate and wider location, as summarised in 'drainage' section 5.4.4, below.

One way of identifying relative flood risk is by way of the Flood Maps NI Map Viewer:

- Flood Maps NI Map Viewer
  https://www.nidirect.gov.uk/articles/check-the-risk-of-flooding-in-your-area

Flood Maps (NI) has been developed to provide a general overview of the flood risk in Northern Ireland. Its main aim is to increase awareness among the general public, local authorities and other organisations, of the likelihood of flooding and to encourage them to take appropriate action to manage the risk. The Climate Change layers reflect the flood plain outlines for the year 2030 and this is based on the best available predictions for the meteorological conditions and sea levels at that time.

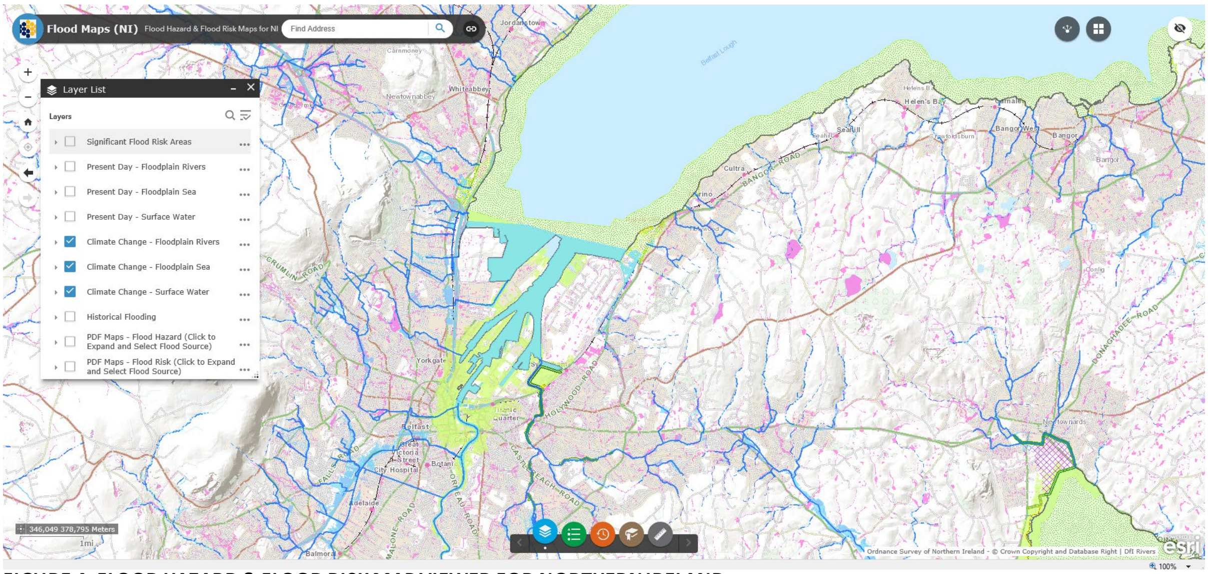


FIGURE 4. FLOOD HAZARD & FLOOD RISK MAP VIEWER FOR NORTHERN IRELAND

This resource enables the display of historical flood layers and present day floodplains for rivers, sea, and surface water; as well as the likely future risk of flooding due to climate change. This resource is hosted on identical software (ESRI) to the Department for Communities, Historic Environment Map Viewer.

Climate Change layers from the Flood Risk NI Map Viewer could be used in conjunction with layers from the Historic Environment Map Viewer. This would provide the opportunity to assess flood risk data relative to historic buildings, and aid owner identification of flood risk to their historic building. Such a resource may be made available in the future.

1.2.4 Erosion

In addition to and in association with location and climate change impact, is the consideration of coastal erosion and the risk this poses for heritage assets. The extent of coastal erosion will be affected by geology, rising sea levels and wave climate that may be affected by an increase in extremes such as storm events.

According to the recent 'Baseline Study and Gap Analysis of Coastal Erosion Risk, 2019, '*Rising sea level is beginning to cause a re-shaping of the NI coastline (CCRA, 2017). Climate change could also contribute significantly to beach erosion because of the predicted increase of storm activity and intensity.' Baseline Study & Gap Analysis of Coastal Erosion Risk Management NI, January 2019*[22]*.*

According to Eurosion (2004), 89km of NI's coastline is eroding – this represents 19.5% of the total NI coastline.[23] *At present, there are no ongoing coast wide*

[22] Department for Infrastructure and Department for Agriculture, Environment and Rural Affairs (2018), p15.
[23] Ibid, p20.

programmes of data collation / research being undertaken along the Northern Ireland Coast.

A publicly available Map Viewer for Coastal Erosion, similar to that shown above for Flood Risk NI, is available in other parts of the UK. However, this is unavailable in Northern Ireland at present. Such data would be beneficial to enable better comparison of existing/potential erosion against the locations of heritage assets, enabling a better understanding of the implied risk.

In the interim, owners should consider the potential risk to their property using their own assessment of vulnerability in light of the above considerations of geolocation, geology, topography and flood risk.

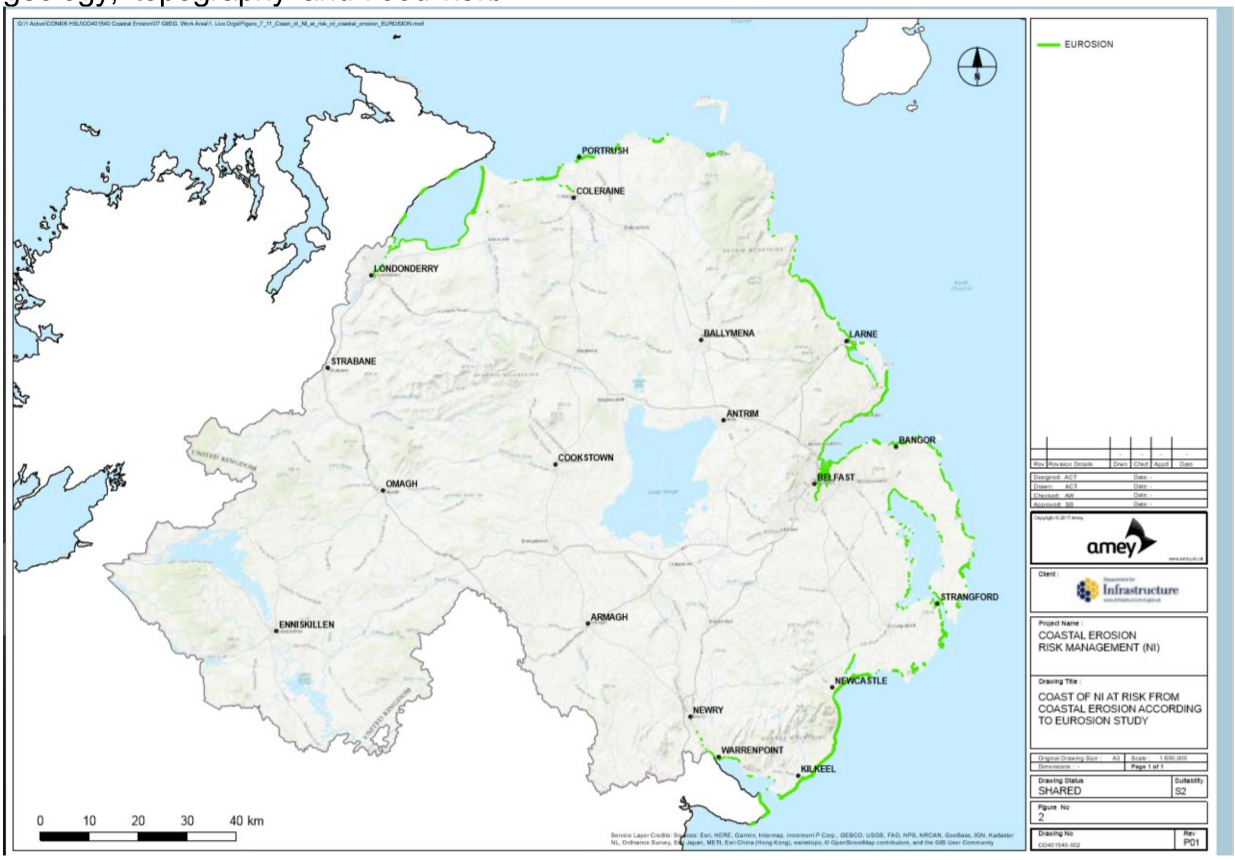


FIGURE 5. EROSION STUDY DEMONSTRATING THE COAST OF NI AT RISK, DFI AND DAERA (2018). HTTPS://WWW.INFRASTRUCTURE-NI.GOV.UK/PUBLICATIONS/BASELINE-STUDY-AND-GAP-ANALYSIS-COASTAL-EROSION-RISK-MANAGEMENT-NI

It is acknowledged that issues of ground erosion may not be isolated to coastal regions and may also occur as the result of coastal, river and surface water flooding. As such, assessment of flood risk, may be seen, in many cases to translate to erosion risk associated with climate change.

RISK ASSESSMENT STAGE 2: SITE

Key considerations for risk assessment:

- **What is the level of mean annual rainfall for the location of the asset relative to other locations in Northern Ireland?**
- **Is the asset on an elevated site or site exposed to south westerly prevailing winds?**
- **Is the asset in relative proximity to the coast or a river?**
- **Is the asset located within the present day Flood Risk NI boundary for coastal/river/surface water flooding?**
- **Is the asset located within the projected 2030 boundary for coastal/river/surface water flooding?**
- **Is the asset on a site that is at risk from erosion or subsidence?**

1.3 MANAGEMENT

In addition to aforementioned factors of 1.TYPE and 2.SITE, the relative risk to a building is influenced by its level of management.

It is well understood that assets that are effectively managed and therefore monitored on a planned cyclical basis, with a robust and systematic management plan in place, will overall be more resilient than those not afforded such attention.

The relative level of adverse effects of weather events and climate related change that an asset is able to cope with will be dictated to some degree by the levels of attention and management afforded to a building more generally in regards to staffing, occupancy, formal or informal monitoring, management structures and monitory condition assessments carried out. This will in turn dictate, to an extent, the immediacy and frequency of mitigation reaction against the impacts of climate change, according the requirements of the asset in the context of variable and increasingly challenging conditions.

For instance, a historic building may be more likely to be occupied on a part or full time basis, while a monument is more likely not, but may be in state care and be *staffed* on a full time/part time basis. The vulnerability of an asset which is not monitored, in contrast to one well managed and monitored, is markedly increased by climate change and its associated increasingly challenging and less predictable meteorological conditions and extremes.

It is also important to consider whether or not an asset is on the Heritage at Risk Register for Northern Ireland:

- The Heritage At Risk Register Northern Ireland
- https://www.ulsterarchitecturalheritage.org.uk/built-heritage-risk/

It is acknowledged that those buildings already on the Heritage at Risk Register have already been given ‘at risk’ status, due to vacancy, poor condition, or other ongoing threats; and the Register may therefore be taken as a marker to prioritise buildings most in need of our attention in the context of climate change.

RISK ASSESSMENT STAGE 3: MANAGEMENT & MONITORING

Key considerations for risk assessment:

- **What is the occupancy/staffing level of the historic asset? Who is tasked with management?**
- **Is a management plan in place?**
- **How frequently are condition checks carried out?**
- **What are monitoring processes?**
- **What is being done to respond to issues arising with regard to condition? Both generally/as a result of impacts of climate change? Materials, detailing and condition assessment/external and internal monitoring/other response?**

As per tables below[24]:

Table 1: Management

Management	Increased frequent Materials, Detailing and Condition Assessment	Increased Monitoring	Increased Response
Fully occupied/staffed	3-4 times/annum and after extreme/compounded weather events.	Monitoring of internal temperature, humidity, material condition, movement, written/visual/photographic condition survey etc.	Maintenance/repair/adaptation/other,
Partially occupied/staffed	4-6 times/annum and after extreme/compounded weather events.	Monitoring of internal temperature, humidity, material condition, movement, written/visual/photographic condition survey etc.	Maintenance/repair/adaptation/other.

[24] Ulster Architectural Heritage (2017)

Management	Increased frequent Materials, Detailing and Condition Assessment	Increased Monitoring	Increased Response
		Additional/meanwhile use where full occupancy is possible/change of owner/occupier.	
Vacant including Heritage At Risk	6-8 times/annum and after extreme/compounded weather events.	Monitoring of internal temperature, humidity, material condition, movement, written/visual/photographic condition survey etc. Additional/meanwhile use where full occupancy is possible/change of owner/occupier. Mothballing where necessary.	Maintenance/repair/adaptation/other.

More information on securing historic buildings/mothballing can be found at: https://www.communities-ni.gov.uk/publications/technical-note-830-securing-windows-and-doors

Table 2: Condition Assessment Seasons

BUILDING ELEMENT	WHEN TO CARRY OUT CONDITION ASSESSMENT
Roofs	Spring & Autumn
Rainwater Goods	Spring & Autumn
Walls – Stone/Brick/Mud/Joints	Spring
Walls – Render	Spring
Windows & Doors	Autumn
Interiors	All Seasons

1.4 Materials and Detailing

Building materials have always been exposed to the elements, and in the instance of the historic built environment this will have been over a considerable timespan. In the future this will add more frequent extreme wind, wind-driven rainfall, and temperature events in addition to many years of 'normal' weathering and age-related deterioration. These conditions placed upon these continually ageing materials, can result in increased moisture-related problems associated with accelerated exterior deterioration of building materials and subsequent adverse impact on internal building conditions. This is of particular significance to historic buildings, as moisture in building materials drives most organic and physical decay[25] , penetrating the skin of a building, adversely affecting the internal woodwork, surface finishes and decoration. Unlike museum objects, buildings cannot be shielded by storage and preservation in an optimum and controlled environment.

Effective moisture and ventilation management strategies are becoming increasingly important in controlling the weathering of building materials. Therefore, how we maintain our buildings and structures may need to be reassessed to deal with the oncoming change in climate conditions.

It is essential to consider the basic, component materials that have been used to construct each individual historic building: the walls, roof, windows & doors, rainwater goods and assess their condition and ability to cope with increased climate stress. This will provide an indication of a building's relative capability to withstand the pressures of climate change.

For example, buildings of solid stone wall construction, built pre-1919, are generally relatively resilient, depending on stone type. A mud-wall building will not have the same level of general material integrity and will depend entirely on three factors for survival: sound roof, good integrity and breathability of interior and exterior rendering; and the maintenance of a dry and ventilated interior. With regard to roof materials, a slate roof or indeed Tin (corrugated iron) over Thatch has 'saved' many such buildings where a thatched roof alone and in poor state may have actually accelerated its decline.

Based on these considerations together, a baseline material assessment may conclude that a solid stone walled thatch building is at lower overall risk than a mud walled thatch. Or that a mud walled thatch building would be at greater risk than a thatch over tin or slate roofed, mud walled building. Considering the basic component

[25] Doehne and Price (2010)

materials of a building is key in identifying headline priorities for protection in the context of maintenance against projected climate change.

In addition to the baseline assessment of physical integrity and the condition of materials, detailed consideration may then be given to the particular qualities or characteristics of a selected material in regard to how likely it is to respond to the impacts of progressive climate change effects. That might be the actual characteristics of the material in terms of its hardness, porosity, resistance or susceptibility to degradation etc., and in situ resilience to weather conditions over a long period. For example the common mistake of using impermeable, and therefore damp inducing, cement render/pointing and paint finishes on a building whose designed construction performance depends on maintaining breathability.

In many cases the resilience of a particular material will be directly related to how that material has been placed in situ, or integrated with other elements of the building fabric. This brings in the soundness of the original design, and assesses its suitability for the characteristics of the materials used in its construction. For example, sills, rainwater goods, lips, and flashings should, if correctly designed, direct water off or away from walls, preventing water ingress and consequent adverse effects on the integrity of principal materials. The original design integrity, together with any previous adaptations, and/or poor maintenance may dictate the relative capacity of details to withstand increased pressures of climate change.

RISK ASSESSMENT STAGE 4: MATERIALS AND DETAILING

Key considerations:

5.4.1 WALLS:

The walls of most heritage assets in Northern Ireland will be masonry – stone and brick, with a much smaller number of historic buildings being of mud and other material construction. Along with roofs & rainwater goods, windows and doors, walls, their material, detailing and maintenance can be seen to be key to keeping water out of a building and help it to face the challenges of climate change.

The physical resilience of both the main wall construction material and the integrity of any render and lime mortar joints may contribute to the capacity of external walls to withstand continued exposure and the projected challenge of increased weather events in the context of climate change. Other general challenges associated with climate change may include increased vegetation, increased mould and algal growth/longer growing season, wetter climate may lead to prolonged saturation of masonry, and long dry and windy spells can increase potential for increased thermal and/or subsidence cracking in walls.

5.4.1.1 STONE:

Northern Ireland's varied geological foundation has provided a wide variety of stone types for use to construct our heritage assets. Typical stone types found in historic buildings throughout Northern Ireland include sandstone, limestone, hard basalt and granite.

Stone constructed walls are, generally, very resilient to daily weathering. Stone may be considered one of the most robust materials in comparison to other primary materials such as local brick or mud walled assets in Northern Ireland. The material integrity of a stone wall may vary with stone type. For example the grain, density and therefore resilience of granite will be better overall than sandstone, or limestone by virtue of being igneous rather than sedimentary. The source quarry for the stone will define the geological structure, character and density, and provide clues to its ability to withstand weathering and environmental conditions. The extraction, cutting, detailing and the integrity of any later repair of stone will also influence its ability to withstand the implied challenges of climate change.

More information on Northern Ireland, buildings and stone type assessment is available via the Stone Database[26]:

- Stone Database
  http://www.stonedatabase.com/

5.4.1.2 BRICK:

Northern Ireland has a rich stock of historic brick buildings, with brick types depending on the level of availability of quality clay and brickworks in any given location. Bricks were historically usually made from clay through a process of moulding, drying and firing.

As with stone, good quality brick is generally very resilient to daily weathering. However, the material integrity of a brick wall will vary considerably dependent of the original source and the relative quality of the clay used, its density, minerology and the suitability for and method used in firing. The resilience of brick may also be influenced by its production processes. Earlier bricks were handmade, with machine made bricks being introduced in the UK towards the latter part of the 19th century.

The production process including the moulding, drying and firing processes may influence the physical and chemical makeup of a brick, and its ability to withstand weathering and environmental conditions and the increased implied challenges of climate change. As an example, a poorly fired handmade Ballycastle Brick, exposed to the elements will absorb moisture and effectively 'dissolve' through time, whereas an engineering grade Belfast or imported hard fired brick will survive almost indefinitely and retain most, if not all of its material integrity. However, other elements of the building may have been designed to direct water away from the building, and therefore the original material, even if not the best quality, is more likely to be resilient over time.

5.4.1.3 MUD:

Mud, earth or clay walls are predominantly found in rural, vernacular buildings. Mud walls are predominantly hand made from a mix of clay and natural occurring fibrous material such as straw or reed, for binding. The clay and natural fibres are typically locally found materials and at times this may include turf or cut sod. The clay may have been moulded into sun/air dried bricks prior to construction, or laid up in wet layers with drying intervals. Sometimes, a mud wall may be found to be encased in another

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[26] See Stone Database, Queen's University, Belfast and Consarc Conservation

material, for example wattle or brick, as well as render. Mud walls are, out of necessity, always rendered.

Mud is the most vulnerable of the three common materials for walling construction in Northern Ireland. The resilience of a mud walled building, being able to withstand meteorological changes, is dependent on the variable quality and constituents of clay, the addition and type of fibre reinforcement in the walls, together with the skill, or lack of skill ,of the builder. The integrity of the render and roof on a mud walled asset is key in enabling this material to withstand weathering, and therefore the additional stresses associated with climate change. In summary, a poorly built thatched building of mud wall construction, in derelict condition, is unlikely to survive without immediate intervention. The adoption of the 'tin roof' has saved many of the surviving examples.

5.4.2 ROOFS:

The roofs of most heritage assets in Northern Ireland will predominantly be slate. A much smaller number of historic buildings will have a thatch roof or roof with tin (actually galvanised iron, or later, steel) over thatch. Together with rainwater goods and associated land drainage, roofs, their material, detailing and maintenance can be seen to be *the* key to resilience, or indeed survival.

The physical resilience of a roof and rainwater goods, particularly the quality of the roofing material used together with construction detailing, repair and maintenance will contribute to the overall capacity of the roof to withstand weathering and the predicted increased challenge of weather events in the context of climate change, particularly the projected increased frequency of extreme rainfall and wind events. As a rule of thumb, a building with a sound roof will stand the test of time even if other elements of maintenance have been neglected.

5.4.2.1 SLATE:

Slate, in terms of its materiality, is widely understood to be more resilient than thatch. True slates are derived from hard, impervious metamorphic rock that can be split into thin layers. Distinct from limestone and sandstone slates, they are associated particularly with Scotland, Wales, Cornwall and Cumbria.

In Northern Ireland, buildings were most frequently roofed with Welsh slates from the 19th century onwards, which are smooth and used in regular sizes resulting in uniform courses. Detailing of eaves, ridge tiles, fixings, etc. may further dictate relative integrity of a roof. Such is the relative resilience of slate that their fixings and their supporting timbers usually deteriorate before slates. Over time, the corrosion of nails ('nail sickness') may cause slates to slip or split, and battens or pegs may decay due to insect or fungal attack.

Primary causes of deterioration in slate may be linked, once again, to the formation of the natural rock and its extraction process from a quarry. Deterioration linked to poor quality includes delamination, whereby slates split into layers and disintegrate over time. The source quarry, extraction, cutting, detailing and quality of slate and not uncommon later poor 'repairs' to roofs using (historically tar) and more recently, mastics, determine its long term (or otherwise) resilience to the projected challenges of climate change.

Although not actually slate, it is appropriate to mention asbestos cement 'slates', and the more recent fibre 'slates', and the role of felt or membrane as a second layer of protection. The manufacture of asbestos fibre cement slate and corrugated sheet, is now banned on grounds of health risk in its manufacture. The material eventually deteriorates through water absorption to an almost 'blotting paper' level and must be replaced with regard to the relevant Health and Safety guidelines for removal and disposal.

Modern fibre slates present no health risk and have a 30 year life. They are often poor aesthetically and theoretically contrary to policy on listed buildings, but do provide a functional roof if already in place.

Most bituminous underfelt will now have become brittle and cracked, thus allowing wind driven rain to permeate the building, often as an 'untraceable' leak. Modern breathable membranes are valuable in the protection of historic buildings with slated or tiled roofs[27].

5.4.2.2 THATCH:

Thatch represents one of the key architectural features associated internationally with all of Ireland. However, today numbers have significantly decreased from around 3000 to less than 150 known thatch roofed buildings in Northern Ireland.

Thatch roofs have traditionally been constructed in often locally grown materials close to the building's location. The thatch is traditionally fixed to a roof in five different ways. Scallop thatch uses wooden rods, spars or scallops to fix bundles of thatch to the scraws. In roped thatch, a network of ropes or net holds down loose bundles of straw or marram grass (this is often used on coastal locations, where thatch roofs are particularly vulnerable due to high winds). Pegged thatch is where ropes are stretched over loose straw and held in place with pegs. Thrust thatch sees straw sewn to the roof timbers with straw ropes, before succeeding layers of small bundles are thrust into the roof using a forked stick (spurtle). Finally, stapple thatch is made up of bundles of straw held into place by daubs of wet clay.[28]

Materials such as reed, straw and flax were, and remain, common, although they are now often imported. It is accepted that materials for thatching have a much shorter lifespan than slate or metal, and rot naturally over time, and are therefore regarded as high maintenance. This varies depending on the selection and quality of materials, detailing, depth, location and relative levels of rainfall. However, when regularly and well-maintained, thatch roofs work very well at directing moisture away from buildings, usually without the assistance of rainwater goods due to the depth and overhang of the roof, and shape of the of the eaves acting to drain water off the roof and away from the building without the need for gutters.

5.4.2.3 TIN OVER THATCH AND CORRUGATED IRON:

Tin over Thatch is a hybrid roof type evolved out of need for a quick, affordable solution to failing thatch, and has preserved many examples of original roof construction that

[27] www.spab.org.uk/advice/true-slate-roofing

[28] NIHE (2004), p14

would have otherwise been lost. Commonly found on modest vernacular buildings in Northern Ireland, what may appear to be a simple corrugated iron roof may often be found to conceal a much earlier thatch roof underneath.

While the resilience of thatch may be extended due to the protection the tin roof affords the natural materials, in some cases the addition of tin on top of a thatch may cause it to be poorly ventilated and lead the materials to 'sweat'. Such practice is generally discouraged nowadays, particularly with listed thatch cottages, where the addition of tin will detract from the historical and architectural character of a building.

However, Corrugated Iron (Invented in England in the 1820s and originally a malleable iron) or 'tin' in the vernacular is, in its own right, an historic roofing and building material. Later sheets were Zinc galvanised mild steel. The little 'tin' Mission Halls of Ulster together with Scout Huts, garages, military buildings, barns and sometimes even dwellings, were not only roofed but completely constructed from this versatile material, once a very common sight in Northern Ireland and now occasionally preserved for their rarity.

Regular painting and replacement of any rusted sheets and guarding against condensation assures a very resilient roof or building.

5.4.3 Architectural Decoration and Construction Details:

Historic buildings can display a variety of distinctive detailing through decoration, architecture and construction. The detail of an historic building is very important to its overall aesthetic, architectural beauty and significance. At times the details we see on historic buildings are simply to add character and ornamentation. More often details that are part of the architectural composition are there for a practical reason; as an exposed part of the roof structure or to make sure water is effectively carried off and away from the building. This is of enhanced importance in the contact of the added weather challenges inherent to climate change. For example, more complex roof geometries on larger buildings can increase the potential for water damage when gulleys and gutters get blocked. See drainage below.

External details such as string courses and hood mouldings, exist primarily as functional elements to shed water and protect the building façade. Often in historic buildings detailing exhibits aesthetic and practical qualities together, the detailing of elements such as rainwater hoppers, projecting eaves, roof pitch, downpipes, etc., were usually well thought out in both style and function. Thus, detailing might be seen to make a doubly important contribution to your historic building serving as both aesthetic and practical.

Robust functional detailing gives historic buildings the best chance of withstanding the impact of increased levels of environmental and meteorological pressures, whereas purely decorative features must be protected for their aesthetic value. In the context of increased pressure on our historic buildings, it is more important than ever that details are in good condition, and any works for maintenance and repair of Northern Ireland's historic buildings is of high quality. Climate change places additional responsibility on owners to take a more proactive approach to maintenance. It also demands a high level of understanding of historic building detailing from conservation professionals, and a highly trained traditional skills and construction work force to complete works on site.

5.4.4 Drainage

The detail and specification of drainage systems, and conditions around a historic building may also affect the level of likely risk from the impacts of climate change. It is always important that water is directed away from a building to avoid water ingress from ground and basement levels. It may be that older buildings have not been designed with sufficient capacity of drainage to facilitate the movement of water in the context of increased rainfall, a rising water table, and the effect of weather extremes. Hardscaping in areas adjacent to buildings, and development leading to loss of gardens or adjacent natural land may also reduce the level of ground water run-off.

Again, monitoring and maintenance, and where necessary, carefully considered adaptation of drainage systems may have to be considered to deal with the impacts of climate change; for example, additional gulleys, traps and soak-aways, or a French drain to perimeter. Run off taking water away from the building will also be facilitated by ensuring land/adjacent ground works slope from the building, and do not direct water towards it, and planting in adjacent areas as opposed to hard surfacing.

5.4.5 Setting

Many historic buildings are enhanced by settings close to mature trees and a variety of climbing plants and creepers. Lengthening growing seasons coupled with increased incidence of heavy rain, and in particular high winds when trees are in leaf, can turn an attractive asset into a potential threat to a historic building, if not properly managed. However, most deciduous trees respond well to even severe topping, which if done in a balanced way by a specialist will usually give the tree a new lease of life and allow it to regain an attractive shape within a few seasons. Conifers are less likely to tolerate topping and some species will die as a result. An exception is the Yew/Irish Yew, which will regenerate enthusiastically.

Sycamore seeds and particularly the fast growing willow must be removed from gutters and valleys before their root systems become established, and trees seeded close to buildings must not be allowed to establish, no matter how attractive in the short term. They will quickly block French drains and damage foundations in the longer term.

Ivy and decorative climbing plants can add character and even an additional breathable protective overcoat to an historic building. However owners must ensure that these are not invasive, entering cracks in masonry or the fabric of roofs and rainwater goods. Such plants should be carefully removed after a ‘cut and let die’ period rather than a damaging wrenching out of living roots.

The last 30 years have seen the mosses and green algae, which were formerly controlled by repeated hard frosts and long winters, now thrive on roofs, walls, flagstones and windowsills. Wind-blown spores and fragments of parent plants together with insect and bird borne media allow them to establish very quickly. Assuming appropriate safety at height precautions are taken, careful use of a long pole with a nail at a right angle through the tip will remove the typical small hemispherical growths from between slates; while the old remedy of a copper wire strung along the ridge will alter the PH of rainfall sufficiently to limit, if not eradicate, growth. Bicarbonate of Soda (baking soda) can be bought by the kilo and is both cheap and environmentally friendly when used to control moss and algal growth.

Some owners will adopt a 'clear and start again' policy, regarding trees and vegetation surrounding an historic property as an unnecessary maintenance responsibility. While some clearance can be beneficial, if overdone, the history and established evolved or planned natural setting of the buildings will be adversely degraded or lost altogether. As with all maintenance, if done regularly it is not onerous, and the results are always rewarding.

RISK ASSESSMENT STAGE 4: MATERIALS & DETAILING

Key considerations:

- **What is the principal material of the walls and roof?**
- **How might the material characteristics of these building materials affect its resilience to climate change?**
- **In what ways do different materials respond to environmental stresses and those in particular that might be affected or enhanced by climate change?**
- **What is the detailing, what are the principal design elements of the details, and relative functionality of each detailed element in helping, or failing, to act to respond to weather events?**
- **What are the key elements of the building's surrounding infrastructure i.e drainage, and how is this performing/or not to direct water away from the building?**
- **What is the setting of the building? Are trees in close proximity? Might trees be at risk of falling in severe winds, is there a high level of leaf fall from trees in proximity?**

While it is acknowledged that some, or possibly many, owners are themselves competent in visually assessing the needs of their particular building. To help owners gain a more in depth understanding of a building it may be necessary to get a survey carried out by a trained professional, who has experience of historic buildings, and where possible is accredited in architectural conservation.

1.5 CONDITION

Once the primary materials of the building are understood, the next step is to take a look at key elements of the building and their particular condition in more detail as per the management and monitoring plan outlined above. Moving through key elements including foundations, walls, roof, rainwater goods, windows and doors, and interiors in a guided framework, identifying key signs of increased stresses of changing environmental and meteorological conditions reflected in the building fabric.

Again, it is acknowledged that some owners are themselves competent in assessing the needs of their particular building, however, it is always recommended that condition inspections be carried out by a trained professional who has experience of historic buildings, and is where possible accredited. It is important to check if planning and/or listed building or scheduled monument consent is required before carrying out any works to your building or monument. It is recommended to contact your local authority or the Historic Environment Division when planning any repairs to a heritage asset.

RISK ASSESSMENT STAGE 5: CONDITION

Key considerations:

- **What is the condition of the building fabric- primary materials and detailing?**
- **What is the likelihood that impact of climate change may be affecting the building or structure's condition?**
- **Why might the condition of the building be presenting evidence of impacts of climate change?**

See table overleaf.

To note:

- ***Regular planned maintenance & repair should be considered as the most straight forward and cost effective response and will deal with the most common instances of climate related stress;***
- ***Adaption should be considered where the maintenance and repair response is not effective to address an issue. Before considering adaptation measures please ensure any necessary consents have been granted should your building structure, or site be listed or scheduled. Please find more information on response to the impacts of climate change in section 6, below.***

Condition:	Condition & Climate Change:	Due to:	Maintenance or Adaptation* Measure
FOUNDATIONS			
Material degradation, subsidence or movement	**Ground shrinkage or expansion resulting in movement of foundations. A rising water table and poor drainage will also have an impact on footings and foundations.**	- **Hotter and drier summers;** - **Increased winter precipitation;** - **Increased number of heavy rainfall events;** - **Run off from adjacent areas;** - **Flash flooding from watercourses and roads.**	- **Ensure exiting drainage features are clear from debris, maintained and functioning;** - **Attend to culverts and adjacent flow-aways/ streams;** - **Routes for surge waters around buildings;** - **Adapt surface drainage and landscaping/ planting;** - **Minimise hardscaping.**
DRAINAGE			
Overflow and/or signs of damp on external/internal walls. As outlined below: Walls. Includes ground drainage and rainwater goods.	**Increased likelihood that drainage systems may not withstand the increase in rainfall. Ground not coping with oversaturation.**	- **Increased winter precipitation;** - **Increased number of heavy rainfall events;** - **Run off from adjacent areas;** - **Flash flooding from watercourses and roads.**	- **Ensure exiting drainage features are clear from debris, maintained and functioning;** - **Attend to culverts and adjacent flow-aways/ streams;** - **Routes for surge waters around buildings;** - **Adapt surface drainage and landscaping/planting;** - **Minimise hardscaping.**
WALLS (STONE/BRICK/MUD)			
Material degradation or delamination	**Increased likelihood of masonry decay and delamination over time, particularly on exposed/SW facing walls due to increased weather intensity.**	- **Increased winter precipitation;** - **Increased number of heavy rainfall events;** - **(>25mm/day) for summer and winter.**	- **Appropriate material and finish of masonry repointing;** - **Improved weathering detailing in architectural elements;** - **External coatings on masonry e.g. harling or lime render.**
Open joints, missing or crumbling pointing	**Increased likelihood of localised failure of mortar joints particularly on exposed/SW facing walls due to weathering/thermal stress.**	- **Increased summer temperatures;** - **Increased winter precipitation;** - **Increased number of heavy rainfall events (>25mm/day) for summer and winter.**	- **Appropriate material and finish of masonry repointing;** - **Improved weathering detailing in architectural elements;** - **External coatings on masonry e.g. harling or lime render.**

Condition:	Condition & Climate Change:	Due to:	Maintenance or Adaptation* Measure
Lichen/algal growths & vegetation	**Increased likelihood of algal growth/vegetation growth on and around masonry due to increased moisture and temperatures.**	- **Increased summer and winter temperatures;** - **Increased winter precipitation;** - **Decreased summer precipitation;** - **Longer growing season.**	- **Ensure rainwater goods and lead work is in good order directing moisture away from surrounding building materials;** - **Improved weathering detailing in architectural elements;** - **Appropriate use of biocides.**
Cracks or displacement of stone/bricks	**Higher likelihood of damage outlined above means higher likelihood of cracks/ displacement, particularly on exposed/SW facing walls. Plus potential additional damage possible from high impact - damage from extreme events.**	- **Increased winter precipitation;** - **Increased number of heavy rainfall events (>25mm/day) for summer and winter;** - **Increased likelihood of compounded & extreme weather events.**	- **Repair with flexible traditional materials e.g. lime mortars;** - **Improved weathering detailing in architectural elements.**
Flaking, cracks or detachment of render	**Additional cracking of render possible due to longer periods of warmer, drier weather.**	- **Increased summer temperatures.**	- **Repair with flexible traditional materials e.g. lime mortars;** - **Improved weathering detailing in architectural elements.**
Wet/damp staining at ground level	**Additional water penetration into wall fabric possible due to increased precipitation flooding/splashback/overspill or blockage of gutters causing damp in walls.**	- **Increased winter precipitation;** - **Increased number of heavy rainfall events (>25mm/day) for summer and winter.**	- **Ensure exiting drainage features are maintained and functioning;** - **Improved weathering detailing in architectural elements;** - **Minimised hardscaping;** - **Adapt surface drainage and landscaping/planting.**
Collapse or risk of collapse of gable wall structure	**Additional likelihood of failure of wall structure as a result of combination of above issues. Plus potential high impact - damage from extreme events leading to wall failure in worst case scenario.**	- **All of the above.**	- **Repair with flexible traditional materials e.g. lime mortars;** - **Improved weathering detailing in architectural elements;** - **External coatings on masonry e.g. harling or lime render.**

Condition:	Condition & Climate Change:	Due to:	Maintenance or Adaptation* Measure
ROOF (SLATE/Thatch/TUT)			
Material degradation of slates/thatch or tin and details i.e. leadwork	**Increase likelihood of roof covering degradation over time, particularly on exposed/SW facing sides due to increased weather intensity.**	- **Increased winter precipitation;** - **Increased number of heavy rainfall events (>25mm/day) for summer and winter;** - **Increased likelihood of compounded & extreme weather events.**	- **Regular maintenance inspections and repairs of materials and fixtures;** - **Additional fastenings to ridges and slates;** - **Improved clips and raggle details;** - **Higher codes of lead.**
Missing sections roof covering missing/damaged tiles/tin/thatch.	**Potential additional damage from high impact - extreme events. Dislodgement of slates/thatch/tin more likely.**	- **Increased number of heavy rainfall events (>25mm/day) for summer and winter;** - **Increased likelihood of compounded & extreme weather events.**	- **Immediate repair and maintenance of fit for purpose materials;** - **Implementation of appropriate temporary covering if suitable.**
Lichen/algal/moss/vegetation growths	**Increased likelihood of lichen/algal/moss/vegetation growth on and around roofs due to increased moisture and temperatures. Particularly relevant to condition of thatch roofed buildings as such growth may interfere with material integrity of thatch.**	- **Increased summer and winter temperatures;** - **Increased winter precipitation;** - **Decreased summer precipitation;** - **Longer growing season.**	- **Maintenance of surrounding overhanging trees to improve ventilation, drying dynamics and sunlight exposure'** - **Improved slating detailing;** - **Improved weathering detailing;** - **Appropriate use of biocide treatments.**
Cracks in chimneys masonry/render	**Higher likelihood of issues outlined above means higher likelihood of damage to chimney masonry/render, particularly on exposed/SW facing walls. Plus potential additional damage possible from high impact - damage from extreme events.**	- **Increased summer temperatures.**	- **Maintenance of chimney fabric;** - **Repair with flexible traditional materials e.g. lime mortars.**
Missing or damaged flashing around chimney/s	**Damage to flashing more likely due to higher levels of rainfall over time and/or high impact - damage from extreme events.**	- **Increased number of heavy rainfall events (>25mm/day) for summer and winter.** - **Increased likelihood of compounded & extreme weather events.**	- **Maintenance of chimney fabric;** - **Repair with flexible traditional materials e.g. lime mortars;** - **Improved flaunching of chimney surrounds;** - **Improved codes of lead and detailing.**

Condition:	Condition & Climate Change:	Due to:	Maintenance or Adaptation* Measure
Damaged or missing rainwater goods e.g. guttering/hoppers/downpipes	**Damage to flashing more likely due to higher levels of rainfall over time and/or high impact - damage from extreme events.**	- **Increased number of heavy rainfall events (>25mm/day) for summer and winter;** - **Increased likelihood of compounded & extreme weather events.**	- **Maintenance of rainwater goods;** - **Repair of rainwater goods;** - **Increase number of downpipes and/or size/capacity of rainwater goods.**
Collapse, or risk of collapse of roof/chimney structure	**Additional likelihood of failure of chimney structure as a result of combination of above wall roof issues. Plus potential high impact - damage from extreme events leading in worst case to roof/chimney failure.**	- **All of the above.**	- **All of the above.**
WINDOWS & DOORS			
Movement/warping/decay of windows and doors	**Increase damp, and humidity causing increased likelihood of timber decay, insect and fungal attacks to windows and doors.**	- **Increased summer and winter temperatures;** - **Increased winter precipitation;** - **Decreased summer precipitation;** - **Longer growing season.**	- **Regular maintenance inspections of materials and fixtures;** - **Use of appropriate materials and use of traditional methods to repair existing fabric;** - **Improved weathering detailing in architectural elements.**
Missing or defective cills/lintels	**Increase damp, and humidity causing increased likelihood of timber decay, insect and fungal attacks to timber lintels.**	- **N/A**	- **Repair or reinstatement of pre-existing elements;** - **Improved weathering detailing in architectural elements;**
INTERIOR			
Smell of mustiness/damp Patches on walls/mould growth	**Increase damp, and humidity causing increased likelihood of timber decay, insect and fungal attacks. May be exacerbated by any water ingress by way of walls/roof, above.**	- **Increased winter precipitation;** - **Increased number of heavy rainfall events (>25mm/day) for summer and winter;** - **Longer growing season;** - **Poor ventilation.**	- **Maintenance of vents, chimneys and air flow around the building;** - **Regular maintenance and inspection of rainwater goods, drains and features directing moisture away from the building;** - **Enhanced drainage adjacent to buildings;** - **Improved water vapour handling on retaining walls**

Condition:	Condition & Climate Change:	Due to:	Maintenance or Adaptation* Measure
Plaster cracking/falling off	**Increase probability of water ingress arising from any unresolved issues outlined above – roof and walls causing plaster failure on interior.**	- **Increased winter precipitation;** - **Increased number of heavy rainfall events (>25mm/day) for summer and winter;** - **Poor ventilation.**	- **Improve natural ventilation;** - **Regular maintenance and inspection of rainwater goods, drains and features directing moisture away from the building;** - **Repairs of external issues with flexible traditional materials e.g. lime;** - **Removal of inappropriate materials e.g. cement.**
Water staining	**Increase probability of water ingress arising from any unresolved issues outlined above – roof and walls causing water staining on interior.**	- **Increased winter precipitation;** - **Increased number of heavy rainfall events (>25mm/day) for summer and winter;** - **Poor ventilation.**	- **Regular maintenance and inspection of rainwater goods, drains and features directing moisture away from the building;** - **Repairs of external issues with flexible traditional materials e.g. lime.**
Splitting/ cupping/ sponginess of wood in internal doors/ floorboards/ skirtings	**Increase damp, and humidity causing increased likelihood of timber decay, insect and fungal attacks which may be exacerbated by water ingress, outlined above.**	- **Increased winter precipitation;** - **Increased number of heavy rainfall events (>25mm/day) for summer and winter;** - **Longer growing season;** - **Poor ventilation.**	- **Improved natural ventilation;** - **Regular maintenance and inspection of rainwater goods, drains and features directing moisture away from the building;** - **Repairs of external issues with flexible traditional materials e.g. lime;** - **Repair or internal elements with like for like materials.**
Collapse or risk of collapse of ceilings/floor boards/features	**Additional likelihood of failure of internal collapse as a result of combination of above interior issues in worst case causing internal structural failure.**	- **Increased winter precipitation;** - **Increased number of heavy rainfall events (>25mm/day) for summer and winter;** - **Longer growing season;** - **Poor ventilation.**	- **Survey of structural timbers for soundness;** - **Improved natural ventilation;** - **Regular maintenance and inspection of rainwater goods, drains and features directing moisture away from the building;** - **Repairs of external issues with flexible traditional materials e.g. lime;**

Condition:	Condition & Climate Change:	Due to:	Maintenance or Adaptation* Measure
			- Repair or internal elements with like for like materials.
SETTING			
Fallen trees or risk of fallen trees in close proximity.	**Additional likelihood of trees/parts of trees falling as a result of storm damage/high winds.**	- **Increased likelihood of compounded & extreme weather events.**	- Survey of trees by a specialist; - Careful pruning or topping of trees; - **Careful removal/ replanting of trees while retaining key elements of historic evolved or planned natural setting.**
Heavy leaf fall causing blockage of gutters and drains.	**Additional growth/leaf fall.**	- **Longer growing season;** - **Increased likelihood of compounded & extreme weather events.**	- Careful topping and pruning of trees; - **Careful removal/ replanting of trees while retaining key elements of historic evolved or planned natural setting.**
*Maintenance & Repair should be considered the more probable and, usually the most straight forward and less costly response; *Adaptation should be considered where the above maintenance and repair response is not effective to address the condition issue. Before adopting adaptation measures please ensure you have received required consents should your building structure be listed or scheduled. Please note that statutory consents will usually apply not only to the exterior but also to adaptation of interiors and setting.			
Based on HES, Table 1: pg.6; Historic Environment Scotland, Climate Change Adaptation for Traditional Buildings, Curtis and Snow, 2016. Adapted by UAH for the purposes of this report.			

1.6 SUMMARY OF RISK ASSESSMENT

The above 5 point Risk Assessment, is a starting point for an owner to identify areas that they may wish to assess further, or upon which they might seek professional advice regarding practical action required to best protect their asset from climate change effects. As outlined, each heritage asset is different, and will be subject to a particular environmental and meteorological context. Though the factors that may affect a heritage asset may be readily identifiable, and even at times, common sense, there is no ‘one size fits all’ assessment of risk to heritage assets in the context of climate change.

To assist, the factors outlined in risk assessment are summarised in the table below. This categorises high, mid and low risks in accordance with each factor.

Each section should be considered on the basis of the individual building or monument, together with the guidance provided in sections 1-5, above, and take in other related guidance and any other available datasets, and professional input on e.g. flood risk, rainfall, geology where these can be accessed by an owner.

Particular attention should be paid in the first instance to the individual factors which are resilient, or susceptible as a result of exposure to the impacts of climate change e.g. site, type, management etc. Action can then be taken in accordance with the importance and urgency of need of each factor arising. One issue can also impact another, for instance the location of a building may attract levels of rainfall that in turn impact elements of condition of the building in a particular way. For example, increased likelihood of localised failure of mortar joints particularly on exposed/SW facing walls due to weathering/thermal stress. The summary table acknowledges that there may be factors not known or not applicable to a particular asset. But where problems have existed in the past e.g. with flooding, or failure of elements of the building, these should be ruled out before looking further.

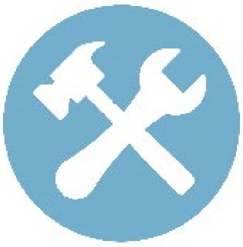
Where a building is at high or medium rating when considered against a specific factor of risk, particular attention should paid to those factors as a priority. Where a risk factor is regarded to be a low rating, it does not mean that such an issue will not present as a risk into the future. As such, underscoring the value of repeating the risk assessment according to the management checks outlined in Section 5.3.

Summary of Risk Assessment– Impacts of Climate Change on the Historic Built Environment in Northern Ireland:*

1.TYPE												
2.SITE LOCATION	**2.SITE TOPOGRAPHY (incl. rainfall, and wind)**	**2.SITE FLOODING (PAST)**	**2.SITE FLOODING (FUTURE)**	**2.SITE EROSION**	**3.MANAGEMENT & MONITORING**	**4.MATERIALS: ROOF**	**4.MATERIALS: WALLS**	**5.CONDITION: FOUNDATIONS**	**5.CONDITION: WALLS**	**5.CONDITION: ROOF**	**5.CONDITION: INTERIOR**	**5.CONDITION: SETTING**
HIGH												
West (incl. NW and SW)	High ground. Comparatively high levels of exposure to rainfall, wind, etc.	Flooded in the Past.	Potential future flooding forecast.	Located in area with existing issues with erosion and/or at close proximity to coast, in the North, East and South East.	Vacant, including those buildings on the Heritage At Risk register	Thatch/No roof (any material), has had one previously.	Mud.	Poor. Material degradation, subsidence or movement of foundations identified.	Poor. Multiple issues of condition/condition that may be further influenced by Climate Change identified with regard to walls. (See table section 5.5). And or evidence of serious failure/collapse.	Poor. Multiple issues of condition/condition that may be further influenced by Climate Change identified with regard to roof/s. (see table section 5.5). And or evidence of serious failure/collapse.	Poor. Multiple issues of condition/condition that may be further influenced by Climate Change identified with regard to interior/s (see table section 5.5). And or evidence of serious failure/collapse.	Poor. Trees in close proximity, at risk of falling. Significant leaf fall, blockages of gutter and drains.
MEDIUM												
Midlands	Mid-level ground. Comparatively medium levels of exposure to rainfall, wind, etc	Threat of flood in the past/near to areas of previous flooding.	Potential future flooding not forecast/flooding forecast, but at lower likelihood.	Located in area near to issues with erosion and/or in an area with potential for erosion.	Partially Occupied/staffed.	TUT/ Partial roof remaining (any material) include roofs with holes.	Brick.	Fair. Early signs of/ possible material degradation, subsidence or movement of foundations.	Fair. Some isolated issues of condition/ condition that may be further influenced by Climate Change identified with regard to walls. (see table)	Fair. Some isolated issues of condition/condition that may be further influenced by Climate Change identified with regard to roof/s. (see table)	Fair. Some issues of condition/condition that may be further influenced by Climate Change identified with regard to interior/s. (see table)	Fair. Significant leaf fall, blockages of gutter and drains.
LOW												
East (inc.NE and SE)	Low ground. Comparatively low levels of exposure to rainfall, wind, etc.	Has not flooded in the past/not near to areas of previous flooding.	Potential future flooding not forecast.	No issues with erosion known.	Fully occupied/staffed.	Slate/Not applicable-not previously a roofed structure.	Stone.	Good. No signs. No issues identified with foundations.	Good. No issues of condition identified with regard to walls. (see table)	Good. No issues of condition identified with regard to roof/s. (see table).	Good. No issues of condition identified with regard to interior/s. (see table).	Good. No trees in close proximity. No issues identified with regard to trees.
N/A: 0	Not known/Not applicable.	Not known/Not applicable.	Not known/Not applicable.	Not known/Not applicable.	Not known/Not applicable.	Not known/Not applicable.	Not known/Not applicable.	Not known/Not applicable.	Not known/Not applicable.	Not known/Not applicable.	Not known/Not applicable.	Not known/Not applicable.

***SEE APPENDICES FOR A WORKED EXAMPLE RISK ASSESSMENT**

RESPONSE TO RISK



Approaches to addressing risk will vary from asset to asset and will be largely dictated by the particular risk factors identified above which may, or may not, be affecting the building or structure's resilience to climate change effects. Response will commonly include addressing issues to do with general condition, but in more unusual instances cases may involve erosion, flooding and long term sea-level rise. Such issues require more particular consideration, including ultimately, whether or not intervention is realistic.

It is advised that an owner considers response to risk in the following order: Monitoring, maintenance and repair first, followed where necessary by the more invasive adaptation, mitigation, relocation/removal, and ultimately, as a last resort, the consideration of managed loss. With the exception of maintenance and 'like for like' repairs, response options are likely to require further detailed assessment, perhaps by a qualified professional and where a building or structure is listed or scheduled and requires statutory consents. This ensures that no adverse and unintended detrimental consequences will arise from unnecessary or badly executed works.

Risk Assessment	**Response to Risk**
Type	Monitoring, Maintenance and Repair
Site	Adaptation
Management	Mitigation
Materials & Detailing	Removal/Relocation
Condition	Managed Loss

Assessment and Response. Response based here on HES, Risk Assessment Triad, Climate Change & the Historic Environment, Ewan Hyslop, 2019.

6.1 RESPONSE: OPTION 1 MAINTENANCE & REPAIR (MOST LIKELY RESPONSE):

It is recommended that owners adopt a 'maintenance first' approach in responding to the impacts of climate change. Monitoring, maintenance & repair should be routine for any historic building owner. 'Maintenance' is defined as activities such as cleaning, painting and minor repairs which are carried out systematically, on a planned cycle, usually annually. The objective of regular maintenance and repair is to eliminate or minimise decay of building fabric and is without doubt the most cost effective way to keep a building in good condition, and ensure resilience in the face of climate change related threats. According to the Society for the Protection of Ancient Buildings, *'Every £1 'saved' by not carrying out preventative maintenance could cost £20 in repairs within 5 years'.*[29]

The majority of historic buildings and structures in Northern Ireland will be most often subject to increased effects of our traditional low to medium impact, frequently changing weather patterns which cause degradation over time. However, when high impact out of season climate change related events are added to the traditional patterns, existing maintenance regimes may not cope. For example, increased loading on rainwater goods due to very high volumes of rainwater delivered in a short period of time with often the addition of strong winds sometimes from an unusual direction.

Effective monitoring and maintenance programmes will require:[30]

- **Regular planned inspections to be undertaken by owners and, where appropriate, by a professional, see Risk Assessment – section 5.3: Management;**

- **Ongoing understanding of the condition of the building via consistent management and timely intervention as a result of regular monitoring, see Risk Assessment - section 5.4: Materials and Detailing and 5.6: Condition;**

- **Response by undertaking systematic planned maintenance and repair works, prioritised where the risk is medium to high, carried out or guided where applicable by experienced and competent professional/ trade / traditional crafts people.**

[29] Edinburgh World Heritage (2019)
[30] Edinburgh World Heritage (2015)

It is recommended that owners read case studies illustrating procedures adopted in maintaining and adapting buildings like their own, and which are facing similar challenges. These, together with practical guides, are readily available and UAH and HED can advise on those most applicable to Northern Ireland conditions and building type.

Examples of Maintenance Guides include:

- **UAH Maintain to Retain (2016):** https://www.ulsterarchitecturalheritage.org.uk/shop/maintain-to-retain-a-guide-to-looking-after-your-historic-building/

- **Department for Communities Historic Environment Division: Buildings Advice & Maintenance:** https://www.communities-ni.gov.uk/articles/buildings-advice-and-maintenance

- **Historic Environment Scotland – Short Guide 9: Maintaining your home (2014):** https://www.historicenvironment.scot/archives-and-research/publications/publication/?publicationid=9b3ca2e8-afcc-42ba-92c3-a59100fde12b

6.2 RESPONSE: OPTION 2 ADAPTATION (ONLY WHERE NECESSARY, & IN ACCORDANCE WITH NI POLICY/STATUTORY CONSENTS):

If good quality general maintenance and repair have been regularly carried out, but are clearly evidenced not to be effective in withstanding climate related challenges, then sympathetic and appropriate adaptation of, in particular, detailing may be the next consideration to best protect a heritage asset (see case study 7.7). That is, for instance, where the detailing of the building or its infrastructure reaches the stage where it is overloaded or that its original design is no longer fit for modern day purpose:

- **increased summer and winter temperatures;**
- **increased winter precipitation**
- **decreased summer precipitation;**
- **increased number of heavy rainfall events (>25mm/day) for summer and winter;**
- **sea-level rise;**
- **longer growing season;**
- **increase in the frequency and intensity of extremes e.g. storms;**
- **increased likelihood of compounded extreme weather events.**

Options for adaptation or mitigation are outlined alongside the relevant Risk Assessment - section 5.5 Condition, above. Adaptation to improve resilience includes innovative, sympathetic changes to existing traditional details, or the appropriate introduction of additional new details to deal with the impacts of climate change, for example increasing the capacity of rainwater goods, by increasing their dimensions and/or through adding additional downpipes. In the case of roofs, for example, adding additional unobtrusive fixings to secure edge slates or increasing overlaps and edge turnovers on lead flashing[31]. Adaptation measures should only be taken where absolutely necessary, and must be carefully executed to be sympathetic, appropriate and compliant with planning policy for the protection of the heritage asset's character, authenticity and setting. If a building or structure is listed or scheduled, adaptation/alteration will require planning permission and Listed Building Consent.

Examples of Adaptation Guides include:

- **Historic Environment Scotland- Short Guide 11: Climate Change Adaptation for Traditional Buildings (2017):** https://www.historicenvironment.scot/archives-and-research/publications/publication/?publicationId=a0138f5b-c173-4e09-818f-a7ac00ad04fb

6.3 RESPONSE: MITIGATION, RELOCATION/REMOVAL OR MANAGED LOSS (EXCEPTIONAL, ONLY AS A LAST RESORT, & IN ACCORDANCE WITH NI POLICY/STATUTORY CONSENTS):

The aforementioned response measures – 1) maintenance, repair and 2) adaptation or mitigation will be the likely measures applicable to deal with the majority of buildings and structures that are experiencing the impacts of climate change.

In most cases, the consideration of relocation/removal or managed loss of an historic asset will only be undertaken after all other solutions have proved impracticable or simply impossible. In a very small number of specific cases these particular options may be contemplated to address, for example a building or archaeological site threatened by catastrophic coastal erosion or encroachment by the sea where sea defences would be ineffective or as is often the case, prohibitively costly. Erosion in Northern Ireland is outlined in section 5.2, Risk Assessment: Site, above.

In terms of these more extreme responses, there must always be well informed debate together with full appraisal of available options, which will need to include all the asset's stakeholders, and usually local and central government, and a consideration of relevant policy before any decision on relocation/removal or managed loss is taken.

Example Site: Skara Brae Neolithic Settlement, Orkney

An example of a heritage site particularly vulnerable to the impacts of climate change is that of Skara Brae in Orkney. The Heart of Neolithic Orkney World Heritage Site comprises a number of very significant remains, including Northern Europe's best-preserved Neolithic domestic settlement at Skara Brae, the Maeshowe chambered burial tomb incorporating 12th-century Viking carvings at the Stones of Stenness circle

[31] Historic Environment Scotland (2017), pp11-13

and henge, and the 104-meter diameter Ring of Brodgar stone circle. UNESCO inscribed the Heart of Neolithic Orkney on to the World Heritage site list in 1999 for '*its outstanding testimony the monuments bear to the cultural achievements of the Neolithic peoples of northern Europe'.*

FIGURE 6. SKARA BRAE NEOLITHIC SETTLEMENT (IMAGE CREDIT: WORLD HISTORY ENCYCLOPEDIA)

In accordance with the requirements of the UNESCO World Heritage Convention the management partners of the site, Historic Scotland, the Orkney Islands Council, Scottish Natural Heritage and the Royal Society for the protection of Birds produced the Management Plan 2014-2019 for the site[32], following on from the earlier 2008-2013 plan.

Subsequently a UNESCO World Heritage Committee report in 2019 warned that Orkney's archaeological treasures are threatened by climate change, saying rising seas, increasing storm intensity and frequency (including the potential for storm surges) and higher rainfall mean the site is extremely vulnerable.[33] The report stated that it was possible that one single extreme storm event could in fact partially destroy Skara Brae, and adversely affect its Outstanding Universal Value.[34]

The findings of the 2019 report have informed the development of a new management plan for the UNESCO site, which is due for release in 2021. Due to the potential for total loss impact on Skara Brae in particular, it is likely that a more interventionist defence based approach will need to be considered here, rather than as will be the case for the majority of archaeological sites.

Skara Brae's European and World significance and its importance to the tourism economy of Orkney coupled to the various specific interests of the managing partners,

[32] Historic Environment Scotland (2016)
[33] Historic Environment Scotland (2019), p47
[34] Ibid.

local residents and landowners, makes achieving the difficult balance of protection and maintaining authenticity, income generation and public access, extremely delicate.

FIGURE 7. SEA WALL AT SKARA BRAE (IMAGE CREDIT: ORKNEYOLOGY.COM)

Skara has been protected by a substantial sea wall since the 1920s, which itself is now threatened by tidal undercut. It seems probable that the wall will be strengthened but inevitably that will have an effect on the neighbouring unprotected coastline. So, one aim is satisfied and another is potentially threatened. Similarly with Orkney now a Cruise Ship destination the detrimental effect of mass tourism footfall on the site is also a significant factor. Such are the problems facing managing authorities worldwide who are now also having to adapt their plans to suit global concerns regarding both climate change and pandemic risk assessment.

In Northern Ireland, the McNeary Westley paper of 2014, *Assessing the Impact of Coastal Erosion on Archaeological Sites: A case Study from Northern Ireland,* commissioned by the Northern Ireland Environment Agency, identified the coastlines most susceptible to climate change related coastal erosion affecting historic assets as the Foyle and Strangford loughs[35]. Phase 2 of this work addressing mitigation does not appear to have been undertaken to date.

This may leave very significant assets such as the Nendrum Tidal Mill in Strangford Lough dating from 787AD and the earliest excavated example in the world, with a very uncertain future.

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[35] Westley & McNeary (2014), p208

7. Case Studies

7.1 Cottage at Mullylusty, Belcoo, County Fermanagh:

FIGURE 8. MULLYLUSTY COTTAGE, 2019. IMAGE CREDIT: ULSTER ARCHITECTURAL HERITAGE

At Mullylusty, Belcoo, County Fermanagh, private owner Margaret Gallagher has over a number of years noticed the impact of changing weather patterns on the thatch at her Grade A listed stone walled cottage. In particular, over the 70 years she has lived in the cottage, Margaret notes that the period of time that a thatch will last before repairs are required is much shorter. She has observed that periods of heavy rain and occasional winter snow now seem to continue later into the year, with spring being more of a continuation of winter than it used to be. Opportunity for the thatch to dry out is less frequent than it used to be, causing more rapid deterioration of the material, particularly causing slipping at the rigging and rotting of the scallops.

In addition, the opportunity to effectively carry out maintenance and repairs (for example, the thatching itself or the application of copper sulphate, 'blue stone') in the necessary dry conditions is more limited now than in the past, with more changeable weather. It is important to note that there are a number of factors that affect the resilience of a thatch roof aside from the weather. This includes the thatching material, how and where is has been grown, together with the way the material has been harvested, where it has been stored, and importantly the standard of thatching workmanship and specification for repairs. However, this case does stand as an example of the increased challenges owners of thatched buildings are likely to face as weather patterns change in response to climate change.

7.2 Cottage at Derrycush Road, Portadown, County Armagh:

FIGURE 9. COTTAGE AT DERRYCUSH ROAD, IMAGE CREDIT: BELFAST TELEGRAPH, FEBRUARY, 2016.

In 2016 at Derrycush Road, Cloncore, Portadown, County Armagh, Dan and Kate McQuillan were faced with the impact of flooding on their B+ listed[36] thatched, mud walled cottage. During the flooding event, action was taken by the owners and the Rivers Agency to try to protect the property with sand bags and pumps. Unfortunately this was not wholly effective as the flooding that surrounded the building on all sides caused significant damage[37].

The proximity of the cottage to the shores of Lough Neagh contributed to the flooding risk but this case is an example of the challenges faced by owners when trying to secure the long-term future of a heritage asset when flooding occurs, and how extreme weather events and lack of infrastructural capacity of drainage networks may impact and increase the risk.

[36] Department For Communities (2002)

[37] Belfast Telegraph (2016)

7.3 GLENRANDAL BRIDGE, GLENRANDAL ROAD, CLAUDY, COUNTY LONDONDERRY:

FIGURE 10. GLENRANDAL BRIDGE, CLAUDY. IMAGE CREDIT: MARGARET MCLAUGHLIN VIA THE IRISH NEWS, AUGUST, 2017. [38]

In late August 2017, is estimated around 60% of the rainfall expected for the entire month fell in just nine hours in counties Londonderry, Tyrone and Donegal. Roads, sports grounds and private homes were damaged in the resulting floods, including the government owned, B2 listed Glenrandal Bridge [39]. This stone bridge, with its abutments and carriageway, built c.1800s[40] was one of five bridges damaged almost 'beyond repair' out of a total of 85 structures affected by the floods.[41] After major repair by the Department for Infrastructure, at a cost of £420,000, the bridge was reopened in 2020[42] forming part of a £20 million repair bill associated with this particular flood event.

This example shows the overwhelming impact that low frequency, high impact rainfall events may have on structures that have otherwise proven to be resilient. It also highlights the importance of forward planning by relevant Departments to identify where there may be risk of such extreme episodes of flooding in the future, and work to plan where possible mitigation against such damage occurring again into the future

[38] Irish News (2017)
[39] Irish News (2020)
[40] Department for Communities (1997)
[41] Irish News (2020)
[42] Ibid.

can be implemented in an attempt to reduce both risk to the historic assets and the public purse.

7.4 Annalong Harbour, Annalong, County Down:

FIGURE 11. ANNALONG HARBOUR

The harbour at Annalong, County Down is a B2 listed stone structure that dates back to the 1840s. It was formerly used to support the local fishing industry and the export of local, Mourne granite. Over many years having proven resilience, in recent years the structure was seen to fall into an increasing state of disrepair.[43] The effect of high impact, low frequency events such as storms and tidal surges, have, over a number of years, caused damage to the pier. In 2018 the local community raised the issue, with owners, Newry Mourne and Down District Council but no action was taken at that time. However, following significant damage caused by a storm in early 2021, work began on the 'deconstruction and reconstruction of the pier' utilising 'all of the traditional materials that were used 150 years ago'[44].

[43] BBC News (2021)
[44] Ibid.

FIGURE 12. DAMAGE TO ANNALONG HARBOUR WALL

This example demonstrates how the accumulation of damage from exposure to low frequency, high impact events such as storms can weaken historic assets in coastal locations. It also highlights the requirement for regular and thorough condition assessment of such structures in exposed locations especially because of the projected increase in the frequency of storms associated with a changing climate.

7.5 MUSSENDEN TEMPLE, DOWNHILL, CASTLEROCK, CO. LONDONDERRY:

FIGURE 13. MUSSENDEN TEMPLE IMAGE CREDIT: GARETH WRAY PHOTOGRAPHY

At Downhill, County Londonderry, on the Causeway Coast, in the 1990s, the National Trust identified risk to the Grade A listed Mussenden Temple. The striking cliff edge setting contributes significantly to the iconic status of this structure but also places it at greater risk of loss through cliff collapse from marine erosion undercutting the cliff face.

Although precise measurements are unclear, it is clear from historic maps and paintings that land in front of Mussenden Temple had been gradually lost since its construction in 1785.

Acknowledging the importance of preserving this iconic landmark for future generations, in the 1990s the National Trust explored various potential management options including the possible relocation of the structure back from the cliff edge. The National Trust eventually decided to stabilise and strengthen the cliff face below Mussenden Temple with the aim of mitigating the impact of coastal erosion and lowering the immediate risk to the building. The works were successfully completed in 1997.[45]

[45] Irish Times (2021)

7.6 Mount Stewart House and Demesne, Co. Down

FIGURE 14. MOUNT STEWART HOUSE AND GARDENS. IMAGE CREDIT: VISIT ARDS AND NORTH DOWN[46]

Mount Stewart house and gardens are one of the best known properties owned and managed by the National Trust in Northern Ireland. The estate is located on the eastern shore of Strangford Lough on the Ards Peninsula in County Down and portions of the formal gardens are at risk from the effects of rising sea level and salt water incursion to groundwater. The National Trust have been developing adaptation plans to mitigate these risks[47] including enhancement of the existing Sea Plantation on the shores of the lough which provides a protective barrier between Strangford Lough and the house and gardens.

John Kerr, General Manager at Mount Stewart outlined the National Trust's response to these challenges: *'Intense rainfall combined with the underlying clay based soils causes river flooding and waterlogging. In particular flooding impacts the Lily Wood and Spanish Gardens. In the summer, drought can cause water shortages when the plants need water the most. The Sea Plantation has a practical function of protecting the seaward part of the garden and plant collection from the salt-laden winds that sweep in from the Lough. Storm surges bypass tidal defences causing inundation and salination in the Sea Plantation.'*[48]

[46] Visit Ards and North Down (N.D)

[47] Department for Infrastructure and Department of Agriculture, Environment and Rural Affairs (2018) p31

[48] The National Trust (2015), p29

However recent climate change studies have suggested that the Sea Plantation will struggle to protect the property over the forthcoming decades and the National Trust have begun a long-term plan to future proof the house and gardens with the possibility of relocating the main car park and replacing it with a dense shelterbelt of trees and shrubs that will take over the protective role of the Sea Plantation. [49]

FIGURE 15. MOUNT STEWART GARDENS. IMAGE CREDIT: VISIT ARDS AND NORTH DOWN

FIGURE 16. VIEW FROM THE TEMPLE OF THE WINDS ACROSS STRANGFORD LOUGH, MOUNT STEWART RED TRAIL. IMAGE CREDIT: WALK NI

[49] Ibid, p21.

7.7 Lanyon Building at Queen’s University, Belfast

FIGURE 17. CENTRAL PORTION OF THE LANYON BUILDING, QUEEN’S UNIVERSITY BELFAST.

The Lanyon Building, Queen’s University Belfast, is another of Northern Ireland’s iconic historic structures that underwent a major programme of refurbishment works in 2019 in response to long-term weathering related deterioration of its external fabric. The works involved the repair and, where necessary, like-for-like replacement of decorative stone detailing in the form of pinnacles, finials and crenelated balustrades. In addition, because of the increasing frequency of extreme rainfall events, rainwater goods were upgraded with installation of larger capacity lead gutters, overflows and outlets, all designed to fit with the character of the existing fabric and detailing.

An original shallow gutter box and 80mm diameter outlet pipe discharged to a hoper and a 100mm square cast iron down pipe.

FIGURE 18A.

A bigger gutter box was formed where the outlet pipe was increased in diameter to 100mm with a 75mm overflow pipe added

FIGURE 18B.

Ensuring that rainwater is efficiently removed from any building is an important component of long-term maintenance strategies. The upgrading of rainwater goods on the Lanyon Building is an example of how a structure can be sympathetically and appropriately adapted to better cope with a greater frequency of intense rainfall events associated with changing weather patterns.[50]

[50] Perspective Magazine (November- December 2019) p20

7.8 Carrickfergus Castle, Carrickfergus, County Antrim

FIGURE 19. CARRICKFERGUS CASTLE. IMAGE CREDIT: DEPARTMENT FOR COMMUNITIES

The early twentieth century flat roof at Carrickfergus Castle was allowing significant ingress of rainwater, resulting in saturated masonry and deterioration of the condition of the wider building fabric. In 2019 the building's owners, the Department for Communities: Historic Environment Division, embarked on a programme of works to address the problem.

The old flat roof was replaced with a new roof that was historically authentic. This featured two individual timber truss slate roofs, with lead valleys and louvered lanterns on top to ventilate the interior; thereby providing effective protection from the weather and good insulation.[51]

During the work, drainage channels laid to falls that passed through the main wall of the keep were uncovered. These original features were utilized to drain the valleys along with new lead rainwater goods installed at three locations to more efficiently carry rainwater off and away from the building.

This is another example of how the introduction of new rainwater goods added to existing channels, which may be seen to address the impacts of a changing climate i.e. more episodes of intense rainfall, with adaptive interventions while adhering to

[51] Perspective (March- April 2020), pp22-24

planning policy which set out that any extension or alteration should be sympathetic and appropriate to the existing building.[52]

FIGURE 20. CARRICKFERGUS CASTLE, REPLACEMENT AUTHENTIC ROOF STRUCTURE

[52] Ibid.

8. Conclusion

This report and guide outlines the climate change associated risks which may threaten the survival and long term sustainability of Northern Ireland's historic built environment. Strategies are proposed to assess, monitor, adapt and mitigate against current and developing impacts. The report highlights the need for building owners and custodians to understand the areas of vulnerability of their assets and then to focus attention on what additional adverse impacts might come into play as a consequence of radically changing meteorological patterns and events - a changing climate.

The report aims to alert owners and custodians of both modest and nationally important historic buildings, that they will inevitably face additional responsibility and more frequent need in caring for their buildings. This will become increasingly important as climate change continues on the present trajectory in line with predictions. However, the report and guide emphasises that dealing with the impacts of climate change will often be a case of lower cost measures through enhancing routine monitoring, maintenance and repair, with appropriate adaptation or mitigation measures required only in the more at risk cases. A small number of cases will need costly, challenging and technically complex intervention in the face of flooding, erosion, or subsidence threat.

A 'maintenance first' approach and a commitment to 'take care of what we have got' is necessary to underpin the overall role that the historic built environment can play in combatting the effects of climate change. Together with appropriate monitoring, maintenance and repair of historic assets, in a changing climate, we must also establish the best parameters for use, reuse and adaptation/mitigation/retrofit/energy efficiency to ensure climate resilience.

At the time of writing there is no official statement or commitment from the Northern Ireland Executive supporting or promoting the use and reuse of historic buildings in the context of climate change mitigation, despite such commitments being already in place across Great Britain and the Republic of Ireland. As the impacts of climate change on the historic built environment are set to continue to increase, the level of support from central government in terms of funding and grant aid for maintenance and repairs continues to diminish at a worrying rate. Northern Ireland funding from a level of £4m in 2015, has fallen to zero for repairs and maintenance in 2020.

Where the need for support for small to medium scale repairs is rising, the financial support from government has been falling, despite the sums required being miniscule in comparison to the value of the Northern Ireland historic asset and overall government spend. This is particularly relevant for private owners who cannot usually access other means of public funding to part finance essential work on buildings which are listed and cared for by owners in the public interest.

This must change if we are to protect our historic buildings for their cultural, historic and economic value while at the same time, maximising the carbon reduction potential of the Northern Ireland built heritage asset. To achieve this benefit in tandem with economic potential for ‘slow’ sustainable tourism and the provision of much needed additional sustainable housing stock, the presumption must always be for reuse rather than demolition.

Further Reading

Maintenance

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SPAB Knowledge Base (2020): www.spab.org.uk/advice/knowledge-base

UAH Maintain to Retain (2016):
https://www.ulsterarchitecturalheritage.org.uk/shop/maintain-to-retain-a-guide-to-looking-after-your-historic-building/

Climate & Climate Change

Adaptation Scotland Supporting Climate Change Resilience (2020):
https://www.adaptationscotland.org.uk/how-adapt/tools-and-resources

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Cadw – A Strategic Approach for Assessing the Impacts of Climate Change on the Historic Environment (2012):
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Derry and Strabane District Council – Climate Change Adaptation Plan 2020-2025 Supplementary Information Document: https://climate.interreg-npa.eu/subsites/CLIMATE/DC_SDC_Supplementary_Information_Document_High_Res.pdf

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NI Adapts – Planning Toolkit (2020): https://www.climatenorthernireland.org.uk/NIAdapts/

The Heritage Council & Fáilte Ireland – Climate Change, Heritage and Tourism: Implications for Ireland's Coast and Inland Waterways Summary Document (2009): https://www.heritagecouncil.ie/content/files/climate_change_heritage_tourism_summary_2009_1mb.pdf

UK Climate Projections (UKCP 2009): http://cedadocs.ceda.ac.uk/1320/1/climate_projections_full_report.pdf

UK Climate Projections (UKCP 2018):
https://www.metoffice.gov.uk/research/approach/collaboration/ukcp/index

Other Resources

Natural Stone Database Northern Ireland:
http://www.stonedatabase.com/

Planning Policy Statement 6 for Northern Ireland (1999):
https://www.planningni.gov.uk/index/policy/planning_statements_and_supplementary_planning_guidance/pps06.htm

Strategic Planning Policy Statement for Northern Ireland (2015):
https://www.planningni.gov.uk/index/policy/spps_28_september_2015-3.pdf

UAH Heritage at Risk Northern Ireland: Review and Recommendations (2019):
https://www.communities-ni.gov.uk/publications/ulster-architectural-heritage-uah-report-heritage-risk

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https://www.gov.uk/government/groups/building-better-building-beautiful-commission

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APPENDICES

See overleaf for a worked example of the Heritage Asset Climate Change Risk Assessment.

Heritage Asset Climate Change Risk Assessment. Name of Building: ___Mullylusty Cottage________ **Date of Assessment** ________January 2020

1.TYPE												
2.SITE LOCATION	**2.SITE TOPOGRAPHY (inc. rainfall, and wind)**	**2.SITE FLOODING (PAST)**	**2.SITE FLOODING (FUTURE)**	**2.SITE EROSION**	**3.MANAGEMENT & MONITORING**	**4.MATERIALS: ROOF**	**4.MATERIALS: WALLS**	**5.CONDITION: FOUNDATIONS**	**5.CONDITION: WALLS**	**5.CONDITION: ROOF**	**5.CONDITION: INTERIOR**	**CONDITION: SETTING**
HIGH												
West (inc.NW and SW)	High ground. Comparatively high levels of exposure to rainfall, wind, etc	Flooded in the Past.	Potential future flooding forecast.	Located in area with existing issues with erosion and/or at close proximity to coast, in the North, East and South East.	Vacant, including those buildings on the Heritage At Risk register	Thatch/No roof (any material), has had one previously.	Mud.	Poor. Material degradation, subsidence or movement of foundations identified.	Poor. Multiple issues of condition/condition that may be further influenced by Climate Change identified with regard to walls. (see table section 5.5). And or evidence of serious failure/collapse.	Poor. Multiple issues of condition/condition that may be further influenced by Climate Change identified with regard to roof/s. (see table section 5.5). And or evidence of serious failure/collapse.	Poor. Multiple issues of condition/condition that may be further influenced by Climate Change identified with regard to interior/s(see table section 5.5). And or evidence of serious failure/collapse.	Poor. Trees in close proximity, at risk of falling. Significant leaf fall, blockages of gutter and drains.
MEDIUM												
Midlands	Mid-level ground. Comparatively medium levels of exposure to rainfall, wind, etc	Threat of flood in the past/near to areas of previous flooding.	Potential future flooding not forecast/flooding forecast, but at lower likelihood.	Located in area near to issues with erosion and/or in an area with potential for erosion.	Partially Occupied/staffed.	TUT/ Partial roof remaining (any material) include roofs with holes.	Brick.	Fair. Early signs of/ possible material degradation, subsidence or movement of foundations.	Fair. Some isolated issues of condition/ condition that may be further influenced by Climate Change identified with regard to walls. (see table)	Fair. Some isolated issues of condition/condition that may be further influenced by Climate Change identified with regard to roof/s. (see table)	Fair. Some issues of condition/condition that may be further influenced by Climate Change identified with regard to interior/s. (see table)	Fair. Significant leaf fall, blockages of gutter and drains.
LOW												
East (inc.NE and SE)	Low ground. Comparatively low levels of exposure to rainfall, wind, etc.	Has not flooded in the past/not near to areas of previous flooding.	Potential future flooding not forecast.	No issues with erosion known.	Fully occupied/staffed.	Slate/Not applicable-not previously a roofed structure.	Stone.	Good. No signs. No issues identified with foundations.	Good. No issues of condition identified with regard to walls. (see table)	Good. No issues of condition identified with regard to roof/s. (see table).	Good. No issues of condition identified with regard to interior/s. (see table).	Good. No trees in close proximity. No issues identified with regard to trees.
N/A: 0	Not known/Not applicable.	Not known/Not applicable.	Not known/Not applicable.	Not known/Not applicable.	Not known/Not applicable.	Not known/Not applicable.	Not known/Not applicable.	Not known/Not applicable.	Not known/Not applicable.	Not known/Not applicable.	Not known/Not applicable.	Not known/Not applicable.

Overall Risk:		Fair. Some isolated issues of condition/condition that may be further influenced by Climate Change increased monitoring and maintenance recommended.