# Myross Wood House, Leap, County Cork

*Retrofit Strategy*

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# 1 Executive Summary

This report has been prepared in response to instruction by NCE Insulation as part of the NPA EU funded Energy Pathfinder Project and sets forth a high-level retrofit strategy for Myross Wood House, Leap, County Cork. As historic building consultants, Carrig Conservation International Ltd have been procured to provide a retrofit strategy for the building fabric. In line with the project brief, recommendations have been provided to improve the thermal efficiency of the building towards the Near Zero Energy Building (NZEB) and Net Zero Carbon Building (NZCB) standards as far as is reasonably practicable without jeopardising the material stability or historic character of the building. Recommendations have been provided on renewable and energy system upgrades to be considered alongside the retrofit strategy, however detailed specifications will need to be provided by engineers specialising in this area.

When altering an historic building to improve its thermal efficiency, it is of utmost importance that the specified material and system upgrades are based on measured data and best practice guidance and research. A holistic retrofit approach must also balance concerns relating to the heritage conservation, fabric preservation, energy performance, embodied and operational carbon emissions and occupant wellbeing. The procedure recommended by I.S. EN 16883:2017 *Conservation of cultural heritage – Guidelines for improving the energy performance of historic buildings* has been used to identify the most suitable upgrade options, which have then been verified by data collected from on-site measurements and a condition survey. The goal of this strategy is to improve the thermal efficiency and reduce carbon emissions as much as possible while minimising the likelihood that any unintended consequences will result from the proposed works. The methodology that follows details the steps and requirements of this holistic retrofit approach.

This Retrofit Strategy may be used by the project coordinators to tender for a single point design team for the next stage of works, who when appointed, will deliver this strategy and develop detailed specifications. It will be of utmost importance that the design team and contractors have experience working with traditional and protected structures. This requirement should form part of any tendering process and experience should be suitably weighted.

# 2 Building Details

Building name: Myross Wood House

Location: Ardagh, Leap, County Cork, P81 Y192

Construction dates: late $18^{th}$ century – late $20^{th}$ century

Orientation: Front elevation of the original $18^{th}$ c. house faces east

Construction type: $18^{th}$ c. house and $19^{th}$ additions are solid masonry and solid brick; $20^{th}$ c. wings are concrete (either solid or concrete block cavity walls)

Floor area: approx. 1300$m^2$

Number of storeys: 2

Thermal improvements to date[1]:

> Walls: Thin (approx. 10mm thick) insulation installed on the internal face of the external walls in the Community Room and Dining Room
>
> Roof: Loose-fill mineral wool insulation (approx. 100 mm) on the flat over the 1959 wing and rolled mineral wool insulation (approx. 100 mm) on the flat over the oldest wing of the building. Both attics were insulated around 2011 and both need to be topped up and checked for condition. Non-breathable roofing felt membranes installed on underside of the roofs and above rafters of both wings.
>
> Windows: Most of the original windows have been replaced at various stages with metal-framed or uPVC double glazed windows. A few single-glazed timber-framed windows remain.
>
> Floors: None

Heating & hot water fuel: Oil

Lighting: electricity

Cooking fuel: oil and gas

Previous function: Private house, then study and training facility for religious practitioners

Proposed function: Alternative Energy Centre (tbc)

Expected hours of use: 24/7

Number of building users: Currently 2 fulltime residents; full capacity 52 bedrooms

Heritage Designation: None, but it is listed on the National Inventory of Architectural Heritage (**Reg No: 20914210)**

Planning Authority: Cork County Council

[1] No definite details were provided by the building owner as to when these improvements were made or by whom, but Father Michael Curran thought the attics may have been insulated approximately 8 years ago.

# 3 Location & Local Environmental Conditions

Myross Wood House is located on a hill overlooking an inlet from the Celtic Sea (Figure 1 & Figure 2). The northern and western sections of the building are built into the hillside and are therefore more susceptible to rainwater run-off and excess moisture accumulation in the building fabric.

*Figure 1. Location of Myross Wood House within the setting.*
*Figure 2. View of the inlet from the entrance road to Myross Wood House.*

As the OPW Flood Map below indicates, Myross Wood House is not at risk of sea level rise or coastal flooding even under the worst climate change predictions.[2]

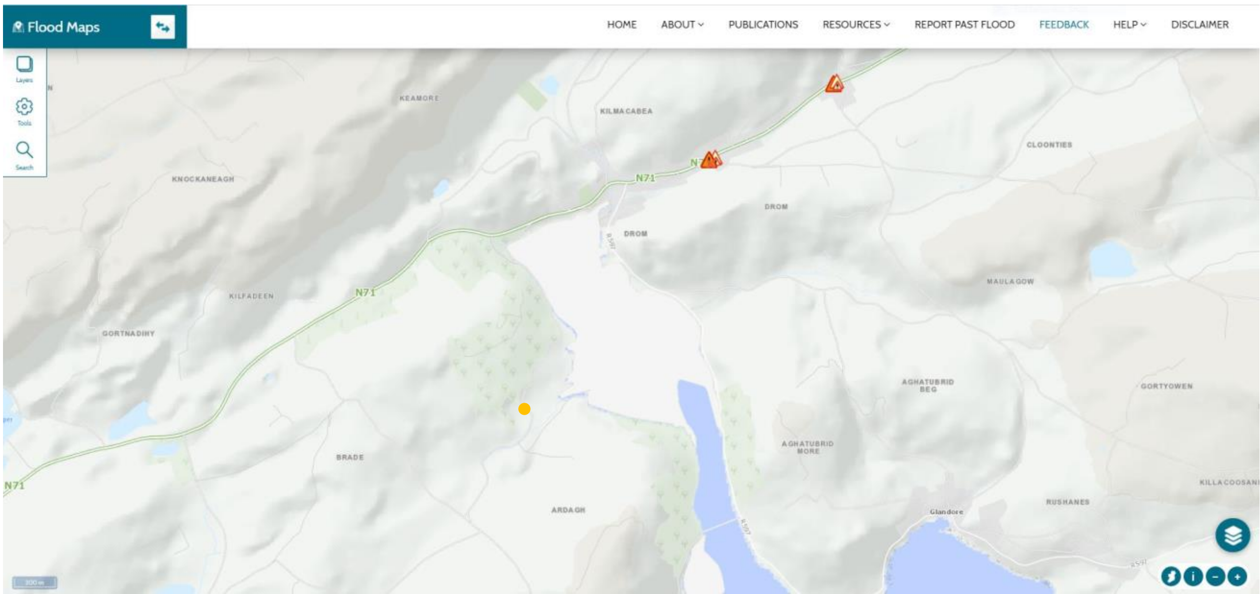



*Figure 3. OPW Flood Map of Leap, Ardagh, Co. Cork with all predictive layers turned on. Myross Wood House is marked with a yellow dot.*

The nearest weather station to Leap is on Sherkin Island. The mean annual rainfall for Sherkin Island from 2017 through 2019 was 1188mm, which is 430mm more annually than what fell on Dublin over the same period (Table 1) (*Monthly Data*, 2020).

[2] The information provided by the OPW Flood Maps has not been altered in any way. The OPW Flood Maps contain Office of Public Works information © Office of Public Works and Ordnance Survey Ireland information © Ordnance Survey Ireland.

*Table 1. Annual rainfall for Sherkin Island versus Dublin Airport.*

Total rainfall in millimetres for SherkinIsland

| Year | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2020 | 105.2 | 96.6 | | | | | | | | | | | 201.8 |
| 2019 | 65.4 | 70.7 | 123.2 | 121.4 | 30.7 | 61.4 | 33.9 | 120.2 | 96.5 | 150.9 | 118.0 | 137.5 | 1129.8 |
| 2018 | 199.1 | 67.2 | 116.6 | 129.3 | 93.0 | 17.2 | 48.8 | 62.5 | 82.7 | 59.5 | 171.0 | 174.1 | 1221.0 |
| 2017 | 66.7 | 78.5 | 132.7 | 14.6 | 39.2 | 112.3 | 89.9 | 78.6 | 150.8 | 115.5 | 51.9 | 147.5 | 1078.2 |
| mean | 132.7 | 101.4 | 94.7 | 73.7 | 73.7 | 75.1 | 78.0 | 88.3 | 92.4 | 127.6 | 120.1 | 130.3 | 1188.0 |

Total rainfall in millimetres for DUBLIN AIRPORT

| Year | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2020 | 36.0 | 83.5 | | | | | | | | | | | 119.5 |
| 2019 | 26.8 | 30.5 | 92.5 | 74.6 | 33.4 | 82.9 | 41.0 | 91.9 | 104.6 | 77.2 | 173.0 | 57.7 | 886.1 |
| 2018 | 93.1 | 36.9 | 100.0 | 68.9 | 19.1 | 4.8 | 40.0 | 48.0 | 43.8 | 42.6 | 131.2 | 81.0 | 709.4 |
| 2017 | 21.9 | 41.6 | 67.2 | 10.0 | 43.5 | 86.4 | 42.2 | 73.2 | 82.3 | 47.8 | 81.5 | 63.1 | 660.7 |
| mean | 62.6 | 48.8 | 52.6 | 54.1 | 59.5 | 66.7 | 56.2 | 73.3 | 59.5 | 79.0 | 72.9 | 72.7 | 757.9 |

Inversely, Skerkin Island receives more solar radiation than Dublin Airport annually (Table 2), which may mean that despite the extra rainfall solar renewables could still be cost effective in this area of the country.

*Table 2. Annual solar radiation levels for Sherkin Island versus Dublin Airport.*

Global Solar Radiation in Joules/cm$^2$ for SherkinIsland

| Year | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2020 | 8545 | 9884 | | | | | | | | | | | 18429 |
| 2019 | 9636 | 14218 | 29091 | 43631 | 62313 | 60847 | 63555 | 50952 | 36773 | 22609 | 12285 | 6666 | 412576 |
| 2018 | 9023 | 15831 | 29709 | 42026 | 58669 | 67070 | 65526 | 44784 | 35609 | 24313 | 8964 | 5613 | 407137 |
| 2017 | 8345 | 14868 | 28307 | 43479 | 57060 | 59325 | 57794 | 46218 | 33526 | 15375 | 11157 | 7084 | 382538 |
| mean | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a |

Global Solar Radiation in Joules/cm$^2$ for DUBLIN AIRPORT

| Year | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2020 | 7855 | 8658 | | | | | | | | | | | 16513 |
| 2019 | 6794 | 15172 | 28541 | 35758 | 48344 | 51880 | 53387 | 45175 | 32004 | 18607 | 7018 | 5534 | 348214 |
| 2018 | 7475 | 14655 | 21659 | 36294 | 56900 | 64896 | 52340 | 39995 | 32175 | 19493 | 6936 | 4254 | 357072 |
| 2017 | 6701 | 10573 | 26799 | 33437 | 57196 | 51592 | 52843 | 39665 | 29850 | 15686 | 9640 | 5499 | 339481 |
| mean | 7228 | 12761 | 25705 | 39407 | 52530 | 52648 | 50860 | 42506 | 30043 | 18168 | 8935 | 5550 | 346340 |

As climate change is projected to cause wetter winters with more severe storms and heavier rainfall, special attention will need to be given to the rainwater goods and drainage systems at Myross Wood House (Daly *et al.*, 2019).

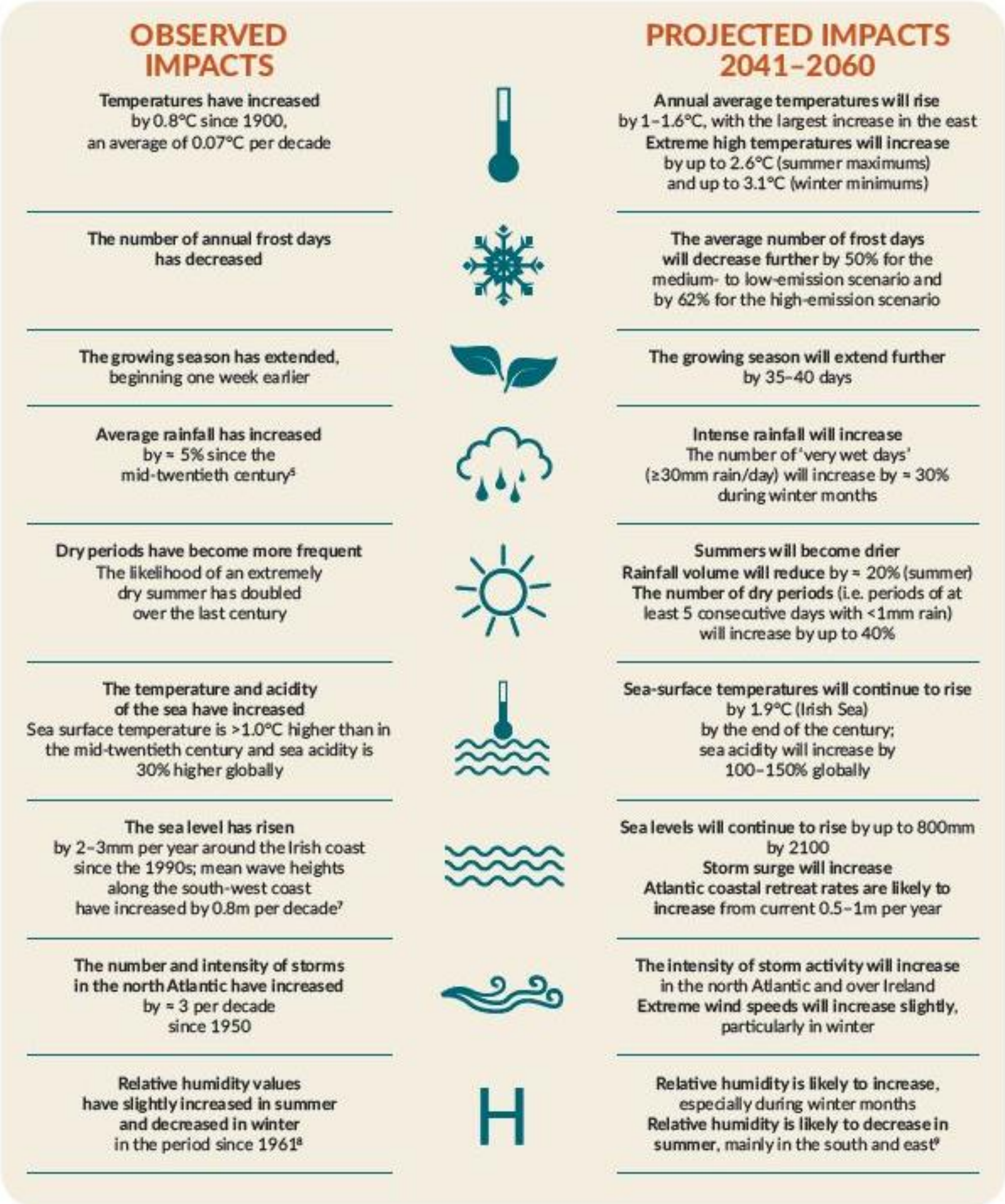



*Figure 4. Summary of observed and projected climate change impacts in Ireland. Source: Climate Change Sectoral Adaptation Plan for Built and Archaeological Heritage (Dept of Culture, Heritage & the Gaeltacht, 2019).*

# 4 Property History & Heritage Value


*Figure 5. Myross Wood House, photograph by Robert French taken sometime between 1865-1914, The Lawrence Photograph Collection (French, ca. 1865-1914).*

The demesne of Myross Wood was purchased by Reverend Arthur Herbert (b. 1726, d. 1785 or 1818), Vicar of Myross and husband to Helena Townsend (b. 1726, m. 1752, d. after 1785) of Castletownsend, and the stately 5-bay Georgian-styled Myross Wood House was likely built between 1752 – 1785 (Townsend and Townsend, 2006a). After Rev. Herbert's death, the house was sold to Lord George King (b. 1771, d. 1839), the 3rd Earl of Kingston, who lived there while he built Mitchelstown Castle (1823-1825). The Earl enlarged the property extending it 'around a courtyard, adding two drawing rooms, five family bedrooms, extensive servants' quarters and utility rooms', plus 22 farm buildings and labourers' cottages (*History*, 2010). A stone marked EK 1819 presumably marks the date of the extensions. *Sketches of Carbery* (1876) records the house as 'a plain, substantial, and commodious-looking house… one of the finest private residences in the south of Ireland' (Townsend and Townsend, 2006b). The property returned to the ownership of the Townsend family when it was purchased by John Sealy Townsend (b. 1764, d. 1852) sometime between 1837 and 1846 and remained in the family until 1943. The house was briefly owned by the Cleary family from 1944-1946 when it was sold to the Missionaries of the Sacred Heart who still own and manage the property. The southern wing of the property was rebuilt in 1959 and the whole property was converted to accommodate a place of religious study and residence for more than 50 priests in training. The west wing of the property was reconstructed in 1987. The property served as a retreat centre from 1970 until recently, but spaces are still let out during the day to community groups.

The original Myross Wood House was a plain 5-bay Georgian house with two symmetrical 2-bay wings set-back with a slightly lower roof level. The original fan-lighted doorway remains, but the timber Ionic portico has been replaced by a concrete pedimented portico (Bence-Jones, 1988). The exterior of the building has been changed quite drastically since Robert French photographed the building sometime between 1865 and 1914. The simple stone window sills have been replaced on the ground floor with moulded window surrounds topped by a keystone and decorative quoin stones and a stringcourse have been added to the central and set-back portions of the house. The lime-based harling has also been replaced with a painted cement-based pebble dash.

The interior of the original house appears to remain largely unchanged on the ground floor and retains the original layout with central stair and hall, as well as decorative archways, mouldings, cornices, doors, window boxes, etc. The layout of the first floor has been changed, but many of the decorative features remain.

Although the property has been altered extensively both internally and externally over the years, the general proportions of the house remain and much can be done to bring the house back to its original style and to improve its performance purely by reinstating appropriate materials.

Please note, a full heritage assessment was not commissioned as part of this project.

# 5 Methodology

In order to develop a customised Retrofit Strategy in response to the conditions found at Myross Wood House, the following steps were be undertaken:

- Meetings with the project management and design teams to review the project objectives;
- On-site assessment of the building's current condition;
- In-situ u-value assessment;
- On-site measurement of moisture levels within the building fabric;
- Assessment of the adaptive capacity of the building towards optimum energy efficiency;
- Consideration of embodied carbon and the environmental impact of proposed interventions;
- Development of a Retrofit Strategy for the building;
- Final technical discussion will be scheduled with the design team to review the final Retrofit Strategy.

## 5.1 Review of the Project Objectives

Carrig met with the Project Managers and Single Point Design Team (SPDT) on Monday, 13 January 2020 at Myross Wood House to discuss the project scope and objectives. At this first meeting, the team were given a tour of the building by Father Michael and options for future use were discussed.

## 5.2 Condition Assessment

Carrig visited Myross Wood House for a second time on Thursday, 6 February 2020 to undertake a selective condition assessment and u-value measurements. This site visit was undertaken to understand the building's construction, present condition and to inspect relevant areas that may present hygrothermal challenges.

Moisture meter measurements were used throughout the inside of the building to identify individual or serial areas of increased moisture levels. Sources of excess moisture will need to be identified and rectified as part of the building works and certainly before any insulation is installed. Areas of excessive moisture have been marked out on the drawings (see Section 9.1).

Pdfs of floorplans prepared by RKD Architects in 2007 were supplied to Carrig, but the building owners have not been able to find the CAD drawings of the floorplans or any drawings of the elevations. In this instance, Carrig has marked up existing conditions as a layer over the pdfs or images of the external elevations to highlight areas of concern that may present difficulties or restrictions in relation to thermal upgrade options, for instance, due to inaccessibility or the potential for thermal bridging. Information gathered from the condition assessment has also been used to eliminate, where possible, any adverse effects to performance and/or historic fabric.

## 5.3 In-situ U-value Assessment

In-situ u-value assessments provide us with a better understanding of how well the external walls of Myross Wood House are currently performing in terms of heat retention. It is important to know the actual u-values of the external walls at an early stage of the design process to inform whether solid wall insulation is appropriate and indeed necessary, and if so, which type and to what depth of application.

One in-situ u-value calculation was run on Myross Wood House from 15:42 on Thursday, 6 February to 18:00 on Friday, 7 February on the northern corner of the east wall of the office above the dining room (1st floor). This measurement was unfortunately cut short due to Storm Ciara (7 -10 Feb), but the results can still be used as an indication of how well the external walls of the original building are currently performing and what to what extent their thermal performance can be improved (see Section 6.2).

## 5.4 Assessment of Adaptive Capacity

Prior to developing the retrofit strategy for the building, Carrig has assessed the adaptive capacity of the building. All measures to improve the operational energy efficiency and to reduce carbon emissions have been evaluated against their potential to compromise the historic or aesthetic significance of the building.

In this step of the project, Carrig also met with various engineers and renewable/low carbon energy source suppliers to discuss viable low carbon heating and energy systems.

All building works will lead to a spike in embodied carbon emissions due to the removal of old materials and systems and the installation of new materials and systems. It is therefore important that materials with low embodied emissions are given preference and that the upgrade works and new energy systems will lead to lower operational emissions after the retrofit is complete. Carrig has therefore reviewed the carbon emissions of the current energy systems and has given due consideration to the environmental impact of the recommended retrofit measures.

A full life cycle assessment should be completed during the concept design phase of the project. This will require detailed drawings and a full bill of quantities.

## 5.5 Development of the Retrofit Strategy

The Retrofit Strategy for Myross Wood House has been developed in line with I.S. EN 16883:2017 *Conservation of cultural heritage – Guidelines for improving the energy performance of historic buildings* and the latest research and best practice guidance available. The strategy has given preference to low-risk, high-impact measures that are suitable for traditional and historic buildings and that have a low or neutral environmental impact.

Prior to the specification of retrofit measures, clear objectives and targets must be agreed with the design team and building owners. These should be reviewed before implementation of the retrofit strategy and should be based on a full heritage assessment, an updated condition assessment and the results of further energy surveys and tests (see Section 8.4.5 for details). The objectives and targets for energy use should be developed in collaboration with an engineering team experienced with low carbon energy systems and their application within historic buildings.

Using the findings from the conditional assessment, u-value measurement and a review of the environmental impact of the heating system, a long list of proposed retrofit measures was created. Any inappropriate or unsuitable measures have been removed and a short list of measures has been assessed according to the potential risks and benefits they pose (see Section 7.3). Only those measures that comply with the physics and heritage requirements of the building have been included in the final proposed interventions (see Section 8). In line with conservation convention, any intervention must be as reversible as possible and a cautious approach of doing 'as much as necessary and as little as possible' has been followed.

## 5.6 Technical Discussion

Following the submission of the Retrofit Strategy, Carrig will meet remotely with the project coordinators to discuss our recommendations, any particular concerns and what can be achieved within the building and budgetary constraints.

# 6 Survey Findings

## 6.1 Condition Assessment

A Condition Assessment of the primary ground floor rooms and attic spaces was conducted at Myross Wood House on 6 February 2020. The key findings from the Condition Assessment are outlined below and areas of concern have been marked out on the plans and images of the building (see Section 0). The limitations these findings present have been accounted for as part of the *Impact Assessment of Retrofit Measures* under Section 7.3.

The Condition Assessment should be reviewed alongside the condition drawings found in Section 9.1.

*Please Note*: No opening up works were undertaken as part of this contract and it is therefore not possible to determine the exact build-up of the walls or underfloor areas. This will need to be done before detailed retrofit specifications can be made.

### *6.1.1 External Elevations & Grounds*

Externally, a large portion of the grounds surrounding the house have been covered in hard, non-permeable materials (concrete or tarmac) that abut the building walls. Underfloor vents to the front of the original house have been left open, but the ground level has risen by approximately 30cm since the construction of the original house (Figure 6). These hard surfaces will be contributing to rainwater absorption by the external walls.

The external walls of the original house appear to have been re-rendered with a hard concrete pebbledash, which will be inhibiting the natural evaporation of excess moisture (Figure 7).

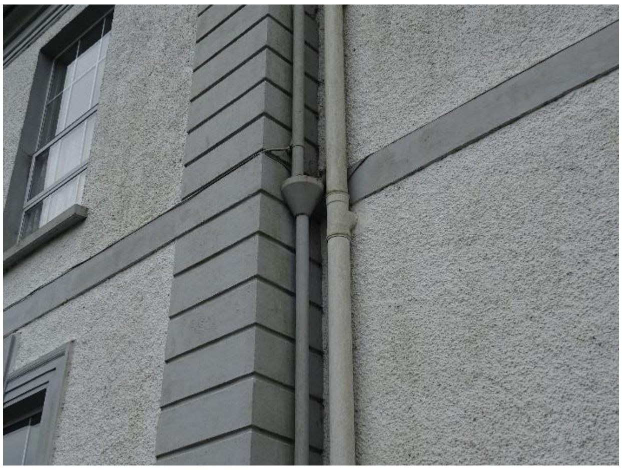



*Figure 6. Opening to underfloor vent on the eastern elevation.*
*Figure 7. Cement based render and finishes on the eastern elevation of the original house.*

The concrete surfaces and walls in the trench around the northern and western wings of the building are particularly damp and are covered with biological growth (Figure 9 and Figure 9).


*Figure 8. Biological growth in the trench around the northern elevation.*
*Figure 9. Biological growth in the trench around the western elevation.*

### *6.1.2 Roof & Attic*

Signs of localised water ingress were found in the attic above the original house with rafters showing decay (Figure 10). White staining on the rafters may be a symptom of condensation build up caused by a non-vapour permeable membrane (Figure 11). Water ingress has also been noted in the eastern wall of the Chapel, so a close inspection of slates and flashings around this chimney stack should be undertaken (see Section 6.1.9, Figure 44).

Previous concrete repairs have been made to the chimney stack in the attic above the original house (Figure 11).


*Figure 10. Evidence of localised water ingress in the rafters above the original house.*
*Figure 11. Concrete repair to the chimney stack in the attic above the original house.*

A black roofing felt membrane has been installed above the rafters in the eastern and southern wings of the building (Figure 12 and Figure 13). This membrane is not breathable and is likely trapping moisture, as is evident by the white residue on the roofing timbers in Figure 13.

*Figure 12. Non-breathable roofing felt membrane used in the attic space above the southern wing.*
*Figure 13. The white residue on the rafters above the eastern wing may be a symptom of condensation caused by the non-vapour permeable membrane.*

A loose-fill mineral wool insulation has been blown on the flat over the southern wing (Figure 14) and a rolled mineral wool insulation has been laid on the flat over the eastern original wing of the building (Figure 15), both at a depth of approximately 100 mm. The blown insulation appears to be in better condition than the rolled insulation, but both will need to be checked for moisture content and condition before any further insulation is added.

*Figure 14. Loose-fill mineral wood insulation over the southern wing.*
*Figure 15. Mineral wool roll insulation over the eastern wing.*

### *6.1.3 Windows & Doors*

A variety of windows and doors exist in Myross Wood House of various ages, forms and stages of decay. The inner front door, fanlight, side windows and columns are likely original to the building, however the entrance portico has been changed significantly (Figure 17, see also Figure 5). The mouldings of the portico have cracked in places and the paint on the timber window frames is peeling.


*Figure 16. The pedimented portico is not original to the building, however the interior door, fanlight and side windows likely are.*
*Figure 17. Deterioration around the portico door frame and window frames.*

Aside from the windows around the interior door, no original windows remain on the eastern elevation. Most of the replacement windows are stylistically sensitive uPVC and all seem to be in acceptable condition (Figure 18 & Figure 19).


*Figure 18. Replacement uPVC windows on the southern wing of the eastern elevation. Most but not all replacement windows are stylistically sensitive with the age of the building.*
*Figure 19. uPVC windows on the southern elevation. All appear to be in acceptable condition.*

A few older timber framed single-glazed windows remain in the building (Figure 20 & Figure 21). Most of these are in need of repair.

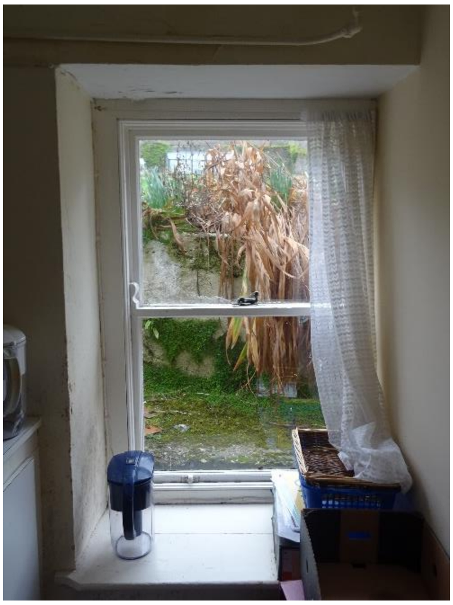


*Figure 20. Timber framed single-glazed windows on the northern elevation.*
*Figure 21. Timber framed single-glazed window in the Foyer of the North Wing.*

### *6.1.4 East Wing - Original House*

The eastern wing of the house is the oldest part of the complex, dating from perhaps the late 18th century. The floors are suspended timber covered with carpet in the parlour, library and community rooms and with vinyl in the dining room. The walls are solid masonry between 660-700 mm thick with an internal lime plaster and wallpaper. The windows have all been replaced with metal or uPVC double-glazing, which remain in good condition. The internal shutters are all still existing and operable but need some repairs. The rooms retain their historic ornamental cornicing, window and door frames.

The parlour and library to the south of the entrance hall are in good condition and are not showing any worrying signs of excess moisture or deterioration. A fireplace has been blocked up in the parlour and it is likely one has been blocked up in the library as well. If reinstated, these could be used as ventilation shafts for a centralised ventilation system. A unique archway with fine detailing connecting the library and parlour has been well maintained (Figure 22). The cornices within these rooms are in very good condition (Figure 23), although the panelling and shutters are in need of some repairs (Figure 24). The sunroom off the Library is in good condition (Figure 25).

*Figure 22. The archway and panelling may have been installed while the building was occupied by the 3rd Earl of Kingston.*
*Figure 23. The cornices in the Library and Parlour are in very good condition.*

*Figure 24. Panelling and shutters around a window in the Parlour need general repair.*
*Figure 25. Sunroom within the Library.*

The interior face of the exterior walls of the Community Room and Dining Room to the north of the entrance hall have been internally insulated with a non-vapour permeable polystyrene insulation layer at least 10 mm thick (Figure 26). This has caused a large amount of interstitial moisture to build up in the walls, which has led to mould growth on the wallpaper from floor to ceiling (Figure 27). Condensation and mould were also found behind the shutters as this area is colder that surrounding surfaces (Figure 28). An internal leak in the southwest corner of the Dining Room has damaged the historic ornamental cornicing.

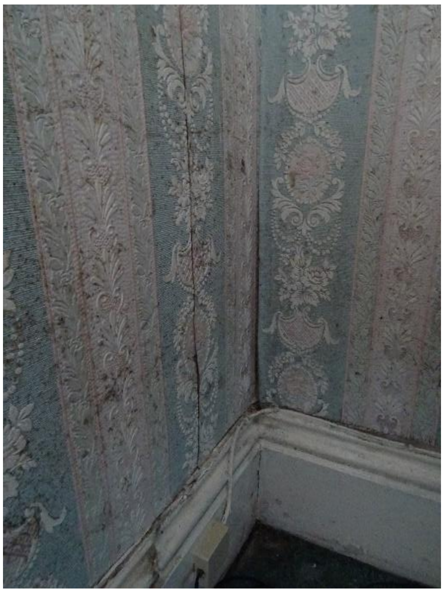


*Figure 26. Thin polystyrene 'insulating wallpaper' found behind the wallpaper.*
*Figure 27. Surface mould on the wallpaper over the polystyrene wall insulation.*


*Figure 28. Mould caused by condensation on a cold spot behind the shutters in the Dining Room.*
*Figure 29. Damage caused by an internal leak above the Dining Room.*

### *6.1.5 North Wing - Kitchen & Laundry*

The Kitchen and Laundry in the north wing to the west of the Dining Room appear to be constructed of solid masonry for exterior walls (670 mm) and solid brick for internal walls (1000 mm). The floor of these rooms is approximately 1 metre lower than the Dining Room and is probably built upon the early level of the external ground floor. A drainage gallery was found underneath hallway outside the Laundry Room, which may indicate that this level is built upon sleeper walls with space for natural ventilation below (Figure 30). The underfloor area and drain are constructed of stone and rubble. The hallway floor is covered with 150 x 150 mm ceramic tiles.

A structural beam spanning east-west within the Kitchen may have been installed to support a later addition of upper floors to the existing building (Figure 31). The ceiling has some cracks and may be a painted concrete slab. Given that the wall depth and construction of the Kitchen corresponds with the oldest part of the house, it is possible that this portion was added by the 3rd Earl of Kingston during the early 19th century and that the roof structure was altered to add the upper floors in the 20th century.


*Figure 30. Drainage gallery below the hallway floor outside of the Kitchen and Laundry Room.*
*Figure 31. The Kitchen within the North Wing was likely built by the 3rd Earl of Kingston when he extended the house during the early 19th century.*

Much of the exterior walls in the kitchen have been lined with stainless steel kitchen cabinets and backsplashes, so it was difficult to survey but there are some signs of dampness. Rising damp appears to be a reoccurring problem throughout the ground level of the building, which is caused by excessive ground water moisture that moves up through the walls by capillary action. This is causing material decay in the building fabric, which is further affected by the non-permeable surface finishes that do not allow the excess moisture to evaporate. The northwest corner of the laundry room is very damp at the base of the wall. Otherwise the room appears to be in ok condition.

The windows are uPVC and are in good condition.

### *6.1.6 North Wing - Retreat Lounge, Dining Hall, Washing Up Room & Foyer*

These rooms were built on a higher level than the kitchen and laundry and are slightly higher than the level of the original house. The Dining Hall, Washing Up Room and Foyer all have a raised timber floor, which is covered by vinyl flooring in the Dining Hall, while the Retreat Lounge has a concrete floor covered by carpet. The walls are constructed of concrete (650 mm). The windows are a mix of metal framed double glazing uPVC in the Retreat Lounge and Dining Hall, two newer single-pane timber sash windows in the Washing Up Room and a single historic single-pane timber sash window in Foyer.

The exterior walls of the Retreat Lounge, Dining Hall, Washing Up Room and Foyer are all showing signs of damp (Figure 32, Figure 33). The carpet over the southwest corner of the Retreat Lounge is wet and a dehumidifier is being used in the room to remove the excess moisture (Figure 34, Figure 35). The ground level outside this room is above the ceiling level, but a retaining wall the width of a walkway separates the soil from the exterior of the building. The base of the trench is covered with concrete, which causing rainwater to be absorbed by the walls rather than the ground. Ivy growth up to the roof of the northwest corner may also be blocking gutters and causing rainwater overflow (Figure 36).

*Figure 32. Staining along the lower level of the external wall in the Washing Up Room indicates persistent issues with rising damp.*
*Figure 33. Damp in the northwest corner of the Dining Hall.*

*Figure 34. Retreat Room – both the northwest and southwest corners are showing signs of persistent damp.*
*Figure 35. Damp in the northwest corner of the Retreat Room*

*Figure 36. Ivy growth on northwest corner of the building. Note that the Retreat Lounge level is fully below ground.*

### 6.1.7 West Wing - Lounge & Hall

The Lounge and Hall in the western wing are constructed of concrete walls (650 mm) and floors. These rooms are also showing significant signs of damp in the external walls to the west where the external trench is lined with concrete (Figure 37). The timber floorboards in these rooms were also rotting in places due to excess moisture (Figure 38).

The cloister along the internal courtyard is constructed of solid concrete walls (220 mm) and solid concrete floors covered with ceramic tiles. Both are in ok condition.

*Figure 37. Damp conditions found within the external wall of the Lounge and Hall of the West Wing.*
*Figure 38. Rotting timber floorboards were found throughout the West Wing.*

### *6.1.8 South Wing - Tearoom & Store*

The Tearoom and Store to the southwest corner of the complex were constructed of concrete walls (500 mm) and a solid concrete floor, which are both in ok condition. There are signs of an internal leak and previous repairs around the pipe work in the northwest corner of the Tearoom (Figure 39). The vinyl tiles measure $30cm^2$ and may contain asbestos (Figure 40). The windows within the Store are timber framed and single glazed. These are in ok condition.

*Figure 39. Internal leak within NW corner of the Tearoom.*
*Figure 40. Vinyl (potentially asbestos) tiles in the Tearoom and Store.*

### *6.1.9 South Wing - Chapel & Conference Room*

The Chapel and Conference Room were constructed in 1959 of concrete walls (480 mm) on a solid concrete floor (Figure 41). The Chapel appears in good condition except for the water ingress around the defunct chimney within the eastern wall which is damaging the timber wall panelling (Figure 42). The eastern wall of the Chapel is likely solid masonry (700 mm) and may have been an external wall to the original house. The Conference Room appears in good condition (Figure 43). The rooms are heated every morning and evening with conventional radiators.

*Figure 41. South Wing (1959) abutting the southern portion of the original house (now East Wing).*

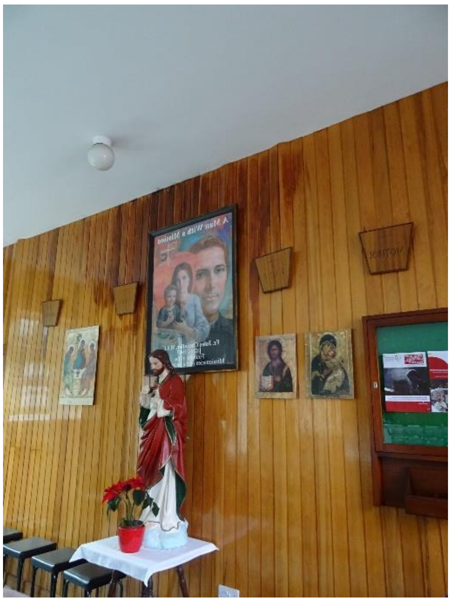


*Figure 42. Rainwater ingress around the defunct chimney stack in the east wall of the Chapel in the South Wing.*
*Figure 43. Conference Room in the South Wing.*

## 6.2 U-value Assessment

### *6.2.1 In-situ U-value Assessment Results*

greenTEG

**Measurement result:**

**Logger data:**

| | | | |
|---|---|---|---|
| Serial No: | 327429 | | |
| Type: | U-value measurement kit | Inside temp. (T1): | 18.5 °C |
| Sensitivity: | 12.7 uV/(W/m²) | Outside temp. (T2): | 15.5 °C |
| Config.: | CB125BA | Measurement time (t): | 98.95 h |

**U-value analysis using average method (Section 7.1, ISO 9869-1:2014):**

| | | | |
|---|---|---|---|
| Analysis start time: | 2020-02-06 15:42:40 | U-value w/o last 24h (U24): | 4.87 W/(m²K) |
| Analysis end time: | 2020-02-10 15:42:40 | U-value first 2/3 (U2/3): | 3.43 W/(m²K) |
| Analysis period: | 96 h | U-value last 2/3 (U2/3): | 33.98 W/(m²K) |
| U-value: | 4.95 W/(m²K) | dU24: | 1.7 % |
| | | dU2/3: | -163.3 % |
| | | dR24: | -10.2 % |
| | | dR2/3: | -2702.0 % |

Measurement data is not suitable for an accurate U-value calculation in accordance with ISO 9869-1:2014.
U-value fluctuations are too high (see standard section 7.1).

**Additional comments:**

Myross House - E wal

**Measurement overview over t=98.95 h**

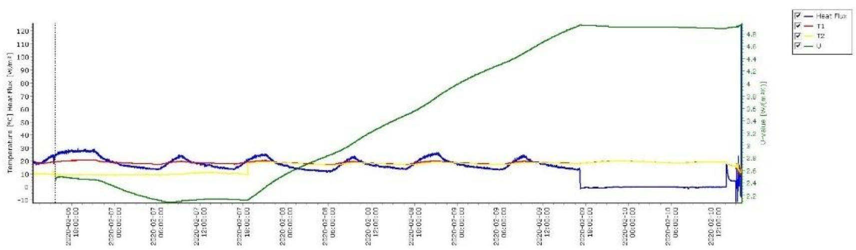


*Figure 44. Output from the in-situ u-value measurement undertaken at Myross Wood House.*

Figure 44 shows the output from the in-situ u-value measurement undertaken on the northern corner of the east wall of the office above the dining room at Myross Wood House from 15:42 on Thursday, 6 February 2020 until approximately 18:00 on Friday, 7 February 2020 (see Figure 49 for exact location).

*Please Note*: This data requires some interpretation due to the onset of Storm Ciara on Friday, 7 February. As one can see, the measured u-value (green line) takes a dramatic leap from approximately 18:00 onward on Friday, 7 February. This corresponds to when the external sensors were removed from the external face of the wall and brought inside to protect them from rain damage. This intervention has skewed the readings in the overall output as the sensor was not turned off until Monday, 10 February when Carrig was able to retrieve it. However, we can see from the diagram at the bottom that the u-value had essentially flat-lined for 12 hours from 06:00 to 18:00 on 7 February at approximately 2.1 W/(m²K).

This u-value corresponds with the default value provided for solid walls in the Dwelling Energy Assessment Procedure (DEAP) used to calculate dwelling Building Energy Ratings (BERs). Although we were hoping to find a lower u-value given the thickness of the wall (700mm), this higher u-value may be due the material qualities of the concrete render which is a poor insulator and can trap moisture due to its impermeable nature. As water is a conductor, damp walls typically increase the transmission rate of internal heat through the walls by approximately 30%.

#### *6.2.2 Calculated U-value Assessment Results*

To test whether the in-situ u-value measurement at Myross Wood House is accurate, the u-value has also been calculated based on educated assumptions of materials and wall build ups. Without having opened up the wall to determine the exact make-up, we can fairly safely assume that the interior is a lime plaster (approx. 30 mm) applied directly to the solid masonry wall (700 mm, probably limestone). We will assume the external concrete render was also applied at a thickness of 30 mm.

To calculate the u-value of this wall, the methodology specified in I.S. EN ISO 6946:2017 *Building components and building elements – Thermal resistance and thermal transmittance – Calculation methods* has been followed (European Committee for Standardisation, 2017).

First, the thermal resistance of each building materials must be calculated using the following formula:

$R = d/\lambda$

Where

$R$ = thermal resistance in $m^2K/W$

$d$ = thickness of material layer in the component in m

$\lambda$ = design thermal conductivity of the material in $W/(mK)$

So, the thermal resistance of the three materials is as follows:

Concrete render = 0.03/1.15 = 0.026

Masonry wall = 0.70/1.7 = 0.41

Lime plaster = 0.03/0.8 = 0.038

Next , the thermal transmittance (u-value) is calculated as follows:

$U = 1/R_{tot}$

Where

$U$ = thermal transmittance in $W/(m^2K)$

$R_{tot}$ = total thermal resistance in $m^2K/W$

So, the calculated u-value of the wall tested at Myross Wood House is:

U-value = 1/(0.026 + 0.41 + 0.038) = 2.11 $W/(m^2K)$

The calculated u-value of 2.11 $W/(m^2K)$ is aligned with the measured in-situ u-value so we can confirm the reading is accurate.

If the external concrete render was removed and replaced by a moisture permeable insulating render ($\lambda$ = 0.086 W/(mK)), we could expect the walls to be nearly twice as efficient at retaining heat than they currently are.

U-value = 1/(0.35 + 0.41 + 0.038) = 1.29 $W/(m^2K)$

Further recommendations to improve the thermal efficiency of the external walls is provided under Section 8.2.3.

## 6.3 Energy Use & Associated Emissions

Energy sources for Myross Wood House consist of oil for hot water, central heating and the Aga, gas for cooking and electricity for lighting and utilities. Most of the ground floor rooms are heated for approximately 3 hours both morning and evening from October to April.

Current occupancy includes 2 full-time residents, a small number of day staff and group day accommodation from time to time.

Yearly financial sums for all energy sources listed above have been provided by Father Michael Curran and are as follows:

2012: €38,217.00
2013: €32,819.00
2014: €31,537.00
2015: €21,766.00
2016: €22,342.00
2017: €25,556.00
2018: €26,431.00
2019: €23,385.88

Father Michael noted that the drop in costs after 2014 is likely due to a fall in the price of oil and occupancy rather than to any change in operational habits, which corresponds to the average annual heating oil costs in Ireland provided by Statista (Sönnichsen, 2020).

By estimating the quantity of heating oil used based on annual costs provided for Myross Wood House from 2016 - 2019, we can then find the approximate associated carbon emissions for this fuel source. Heating oil emits 2.536 kg$CO_2$e per litre (Hill *et al.*, 2018).

*Table 3. Annual heating oil consumption and estimated carbon emissions for Myross Wood House.*

| Year | Annual cost for heating oil at Myross Wood House | Ave. annual cost of heating oil in Ireland (€/1,000 litres) | Estimated quantity of oil consumed at Myross Wood House (litres) | Estimated carbon emissions for heating oil (kgCO2e) |
|---|---|---|---|---|
| **2012** | | €1,104.20 | | |
| **2013** | | €1,069.20 | | |
| **2014** | | €974.30 | | |
| **2015** | | €677.40 | | |
| **2016** | €15,421.82 | €582.70 | 26,466.14 | 67,118.13 |
| **2017** | €18,251.32 | €632.20 | 28,869.53 | 73,213.14 |
| **2018** | €17,523.85 | €692.60 | 25,301.54 | 64,164.72 |
| **2019** | €17,180.00 | €714.30 | 24,051.52 | 60,994.65 |

To conceptualise the amount of carbon being emitted solely by the oil used annually in Myross Wood House, the following conversions can be used: equivalent square metres of oak woodland required to capture all of the $CO_2$e emissions per year (Ecoscore, 2019); and equivalent number of kilometres that would have to be driven by an average car to release the same amount of $CO_2$e emissions (The Society of Motor Manufacturers and Traders, 2019).

*Table 4. Carbon emissions equivalents in square metres of oak woodland and kilometres driven by car.*

| Year | Estimated carbon emissions (kgCO2e) | Equivalent area of oak woodland required each year to consume all CO2e emitted (sq.m.) | Equivalent distance driven in an average car (km) |
|---|---|---|---|
| **2016** | 67,118.13 | 2,483.10 | 431,281.16 |
| **2017** | 73,213.14 | 2,708.59 | 470,445.88 |
| **2018** | 64,164.72 | 2,373.83 | 412,303.42 |
| **2019** | 60,994.65 | 2,256.55 | 391,933.49 |

## 6.4 BER Estimate

Based on a visual inspection of the building, an advisory Building Energy Rating (BER) assessment has been carried out for the traditionally constructed portion of the building (see Figure 50 for details). Given that measured drawings were not supplied to Carrig, estimated measurements were used and this can therefore only be taken as an advisory BER and cannot be used in any official capacity. To undertake an official BER assessment, detailed measures would need to be provided by the project architects and opening works would need to be undertaken in a number of locations to ascertain the composition of the various wall constructions.

For the traditionally constructed portion of the building:

Estimated BER is **E2**.

Estimated annual primary energy usage is 377,383 kWh/yr.

Estimated carbon emissions for all energy sources is 93,140 kg$CO_2$/yr.

# 7 Adaptive Capacity

The following standards and best practice guidance have been reviewed to determine the adaptive capacity of Myross Wood House to as near NZEB and NZCB standards as possible without compromising the material, historic or aesthetic characteristics of the building. The final Retrofit Strategy gives preference to low-risk, high-impact measures that are suitable for traditional buildings and historic structures.

## 7.1 Best Practice Guidance

### *7.1.1 I.S. EN 16883:2017 Conservation of cultural heritage – Guidelines for improving the energy performance of historic buildings*

European Standard 16883 *Conservation of cultural heritage – Guidelines for improving the energy performance of historic buildings* was approved at the European level in February 2017 and has since been transcribed into Irish Standards (European Committee for Standarisation, 2017). The standard is designed to be used by building professionals to improve energy performance and to lower the greenhouse gas emissions from historic buildings of all ages and types regardless of protected status. The standard presents a normative working procedure to assist designers in finding the most appropriate sustainability measures for each individual building based on investigation, analysis and documentation of the building, including its heritage significance. The standard does not presuppose that all historic buildings need sustainability improvements.

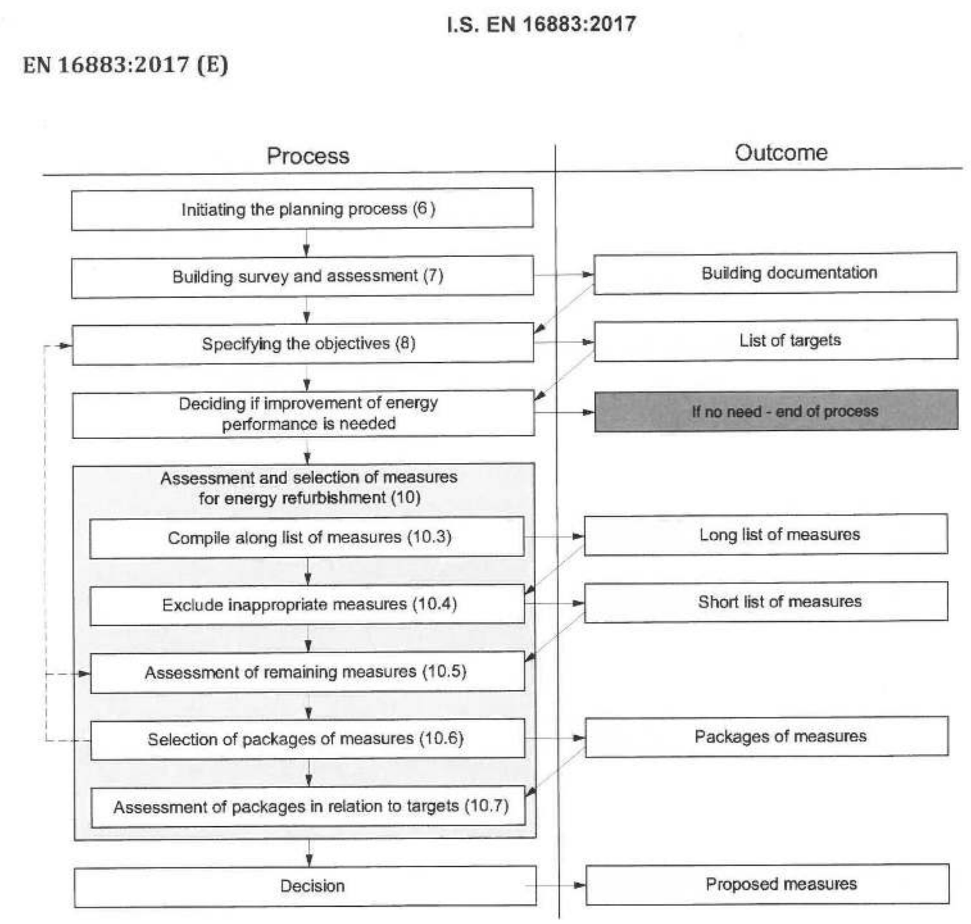



*Figure 45. EN 16883 flow chart showing the proposed procedure to determine appropriate retrofit options.*

### *7.1.2 STBA Responsible Retrofit Guidance Wheel*

The Sustainable Traditional Buildings Alliance (STBA) is an independent, not-for-profit organisation established in 2012 that develops policy, guidance and training to limit the negative impacts on traditional buildings and maximise benefits to the building and homeowners when maintenance, repair and energy renovation works are being undertaken. The STBA has published a number of advisory papers as part of their *Responsible Retrofit* guidance series (May and Griffiths, 2015; May and Rye, 2012; *Responsible Retrofit Series: What is Whole House Retrofit?*, 2016).

The Responsible Retrofit Guidance Wheel (Figure 46) developed by the Sustainable Traditional Building Alliance (STBA) is another helpful decision-making tool which was used to verify the recommended retrofit measures for Myross Wood House (STBA, 2017).

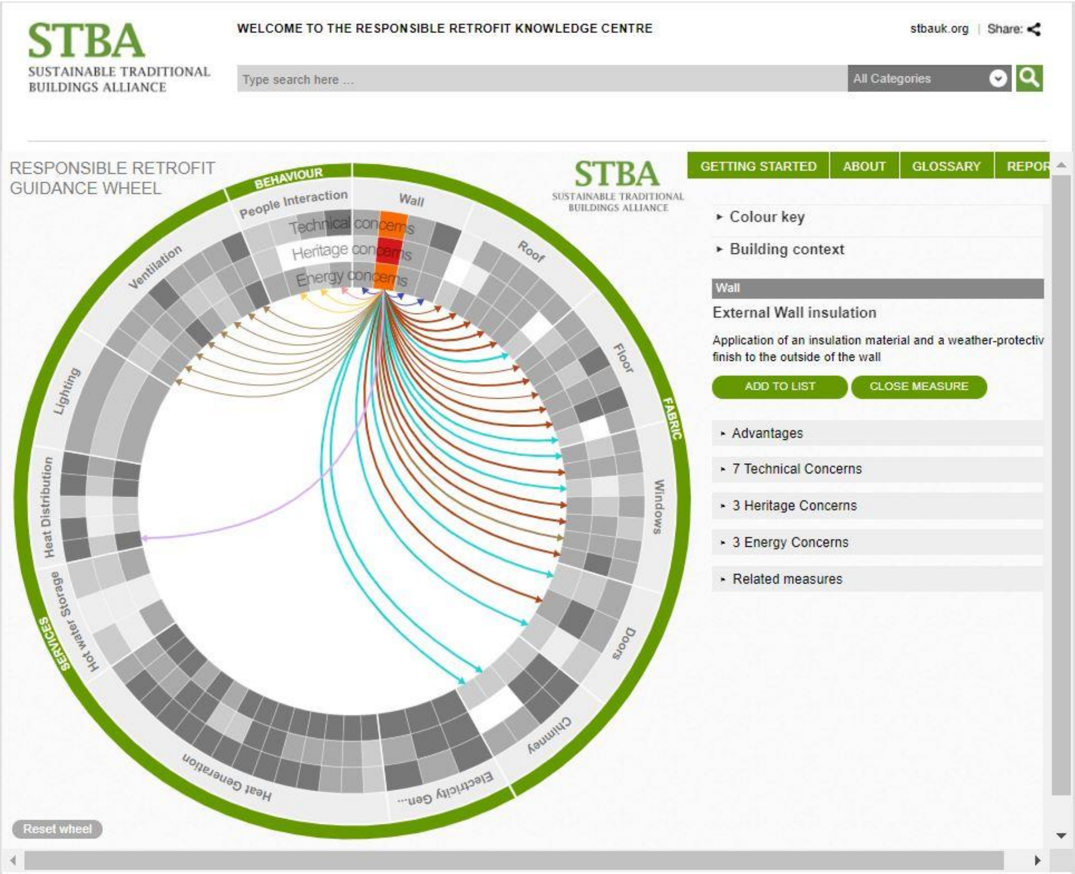



*Figure 46. The STBA Responsible Retrofit Guidance Wheel developed to inform the decision making process.*

### *7.1.3 Historic Environment Scotland*

Historic Environment Scotland (HES) has led the way in producing technical guidance on the refurbishment and retrofit of traditional and historic buildings. Due to the similarities between the Irish and Scottish climates and building traditions, much of the recommended guidance in the HES documents is applicable to the Irish context. The HES Technical Papers, Technical Advice Notes and Refurbishment Case Studies are written with the building and conservation professional in mind and therefore provide a high level of detail on complex matters.

### *7.1.4 Historic England*

Historic England (HE) has also published a number of energy efficiency technical reports under their Research Reports series and more general guidance notes under their Energy Efficiency and Historic Buildings (EEHB) series. The current focus of the Energy Efficiency Research Reports can be summarised in five categories:

- thermal performance of traditional buildings;
- moisture accumulation in building fabric due to energy efficiency measures;
- numerical modelling of hygrothermal behaviour of building fabric as a risk assessment tool;
- 'whole building' approach to energy saving in historic buildings; and
- the SPAB building performance survey.

#### *7.1.5 Additional Resources*

*Sustainable Renovation: Improving Homes for Energy, Health and Environment* (Morgan, 2018) provides principles and details for building practitioners working with the energy upgrade of existing domestic buildings.

*Thermal Insulation Materials for Building Applications* (Latif, Bevan and Woolley, 2019) is a valuable independent review of the performance and environmental impact of numerous insulation products on the market.

## 7.2 Energy Performance Objectives & Targets

The intention behind setting energy performance objectives and targets should be to achieve the best possible energy performance for the building while retaining the heritage significance. These should therefore take into account the construction of the building, current condition, heritage significance, building regulations, as well as the current and likely future building uses and finances. To ensure long-term targets are met, the objectives and targets should also be integrated into a long-term management and maintenance strategy.

For Myross Wood House, some potential retrofit objectives may include:

- Improve energy efficiency
- Improve indoor air quality
- Protect and enhance heritage value
- Promote local employment and traditional building skills
- Use local, low-carbon, sustainable materials

In order to meet these objectives, specific targets should be agreed with the current owners, future occupants and local community users of the building. For instance, one target may be to reduce energy consumption by 25% or to increase the percentage of energy coming from renewables by 50%.

A base will also have to be set to compare savings/improvements against. This can be done through the use of monitoring and surveys.

Given the limited scope of this study, the recommended retrofit measures have been based on the condition assessment, u-value measurement and a review of the environmental impact of the heating system.

## 7.3 Impact Assessment of Retrofit Measures

The *Impact Assessment of Retrofit Measures* for Myross Wood House has been adapted from the format recommended in I.S. EN 16883:2017 to include the level of risk and benefit within a single cell using colour coding and numbers. For this project, the retrofit measures were reviewed against their technical compatibility and impact on heritage significance.

| | **Assessment Scale** | | |
|---|---|---|---|
| **Benefit** | Neutral | Low - Med | High |
| **Risk/Impact** | Low = 1 | Medium = 2 | High = 3 |

| **Compatibility Assessment** | **Assessment Criteria** | **French drain around building perimeter** | **Repair of internal shutters** | **Draughtproof around windows & doors** | **Draughtproofing below suspended timber floors** | **Insulating below suspended timber floors** | **Replace uPVC & metal-framed windows with timber triple-glazed** | **Internal secondary glazing for historic windows** | **Replace concrete floors with insulated limecrete** | **Underfloor heating in limecrete** | **Attic insulation on ceiling level** | **Remove IWI and re-plaster internally** | **Insulating lime render (external)** | **High efficiency gas boiler** | **Solar PV for water heating** | **High temperature AWHP** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Technical / Material** | **Risks** (Hygrothermal, Structural, Corrosion, Salt Reaction, Biological) | 1 | 1 | 2 | 2 | 2 | 1 | 1 | 2 | 2 | 1 | 1 | 2 | 1 | 2 | 1 |
| **Heritage Significance** | **Impacts** (Material, Aesthetic, Spatial) | 1 | 1 | 1 | 2 | 3 | 1 | 1 | 2 | 2 | 1 | 1 | 2 | 1 | 2 | 1 |

# 8 Retrofit Strategy

The following recommendations are based on discussions with the project team and building occupants, the condition assessment (Section 6.1), u-value assessment (Section 6.2) and retrofit impact assessment (Section 7.3).

Each proposed intervention will need to be reviewed with the Project Manager and appointed single point design team (SPDT) prior to finalizing the documentation for cost analysis, planning permission and tendering for construction.

Although Myross Wood House has not been statutorily designated, it retains many of its historic characteristics and heritage value and has thus been treated as a protected structure.

## 8.1 Preparations

### *8.1.1 External Render*

All external render appears to be of a cement base. This should all be carefully removed to get back to the stone substrate of the 18th and 19th century portions of the complex. The render should be removed during the spring to allow the building fabric to dry out over the summer.

### *8.1.2 Ground Water Control*

A damp wall does not perform well thermally so steps will need to be taken to direct rain and ground water away from the base of the building.

All concrete and tarmac abutting the building should be removed and a trench should be dug around the building prior to erecting the scaffold. The intention is to install a French drain system around the internal and external perimeter of the building. Care should be taken to not undermine the foundations of the building.

The removal and replacement of all hard surfaces with gravel would also allow a more natural absorption and distribution of rainwater around the site. This should be done in the courtyard and along the trench to the north and west of the building with the installation of the French drains. The rest of the hard surfaces can be replaced when finances allow. The external ground level should be lowered below the internal floor level at same time.

The retaining walls should also be pushed back to remove the proximity of ground source moisture and could be stepped to allow more sun to dry the exterior walls of the building.

### *8.1.3 Scaffolding*

A full regulation scaffold is to be erected to all elevations of the building. If possible, a scaffold roof should be erected over the building.

## 8.2 External Works

### *8.2.1 Roof*

Regular maintenance is essential to keep the roof in proper working order and to keep the building dry. This includes checking for slipped slates, missing or loose flashings, dislodged or over-flowing gutters and downpipes, loose or damaged brick/stonework, plant growth, and issues with chimneys, chimney pots and waste pipes.

To adapt the building to climate change and the associated higher levels of rainfall and stronger winds, consideration may need to be given to extending the eaves. A larger overhang will direct rainwater further away from the base and walls of building and will reduce the amount of rainwater absorbed by the external walls.

Eaves often present risks for thermal bridging. Care should be taken with the eaves detailing to ensure a minimal risk of thermal bridging.

#### *8.2.2 Chimneys*

Caps should be installed on all chimney pots to keep rainwater out but to allow ventilation.

A thorough inspection of chimneys should be undertaken and mortar and flaunching should be repaired where necessary. Flashing should be checked and replaced where necessary.

#### *8.2.3 Walls*

While the cement render is off the traditionally constructed parts of the complex, any cement pointing and/or open joints should be raked out and replaced with lime mortar.

A lime-based insulating render should be applied to protect and improve the thermal performance of the external walls. The render may contain either hemp or cork, must be suitable for outdoor applications and must not have any cement content. It is recommended that the external render not exceed 30-40mm in depth to allow moisture within the wall to evaporate as quickly as possible. One such insulating render available in Ireland is the Diathonite Cork Render supplied by Ecological Building Systems.

Lime-based insulating renders will improve the thermal efficiency of both solid masonry and solid concrete or concrete block walls. The throughway within the 1959 wing of the building should also be insulated externally.

Lime-based renders are carbon neutral or even carbon negative as they absorb carbon from the air while they cure. As a natural, environmentally friendly, carbon neutral building material, lime-based insulating renders would be preferred over other man-made, petroleum-based, high carbon external insulation alternatives. An external woodfibre board covered with lime render is also a low carbon, natural alternative to externally insulate the solid concrete or concrete block walls.

If the finished external render is to be painted, a diffusion open mineral based paint must be used. Regular water repellent paints will trap moisture and will inhibit the insulating lime plaster to function as it should. Moisture permeable paints are provided by Keim Mineral Paints, Auro Natural Paints and others.

This may be an opportunity to return the oldest part of the house nearer to its original appearance as shown in Figure 5.

#### *8.2.4 Rainwater Goods*

Replacement rainwater goods are to be designed and manufactured in cast iron. Consideration should be given to increasing or oversizing the gutters and downpipes to future-proof against increased rainfall due to climate change. According to Climate Ireland climate change predictions, average rainfall has already increased by 5% since the mid-20$^{th}$ century and it is expected to increase by a further 30% during winter months by 2060.

All existing rainwater drains should be checked to ensure they are clear and dispersing water a safe distance from the building. To determine the requirements of replacement rainwater goods, the performance of existing rainwater goods should first be reviewed during heavy rainfall to see if they are coping with the runoff. Replacement rainwater goods should then be designed to cope with a 30% increase to the average peak rainfall intensity for this region in winter months.

Rainwater harvesting should be considered with a view to producing a grey water solution.

### 8.3 Internal Works

All materials and alterations must be suitable and compatible with a traditional building, and low carbon materials and processes should be prioritised.

### 8.3.1 Attic

Attics and roofs are generally responsible for a large amount of thermal loss if not insulated properly.

The loose-fill mineral wool insulation over the South Wing should be checked for moisture content. If it is dry, further insulation can be added on top to bring it up to the top of the joists. A second layer of rolled natural, moisture permeable insulation should be run overtop the joists in the opposite direction. Care should be taken not to block an existing roof vents and additional roof vents may be required to supply adequate cross-ventilation.

The International Agency for Research on Cancer has classified mineral wool as a Class B carcinogen meaning it may cause cancer in humans (Latif, Bevan and Woolley, 2019). Care should be taken when working with mineral wool and it may be preferable to remove and replace the existing insulation with a natural alternative such as hemp fibre or sheep's wool rolls, both of which are biodegradable, have a low thermal conductivity, are moisture permeable and have no known negative environmental or heath impacts. The soft roll insulation should be laid snuggly between the joists and a second layer should be laid across the joists in the opposite direction.

It was not possible to inspect any other attic spaces, but the recommendations above apply to all attic spaces.

The existing roofing felt membranes at rafter level should be replaced with a moisture permeable airtightness membrane whenever any portion of the roof is re-slated to ensure moisture is not being trapped in the roof timbers. While the membrane is off, the roof should be checked internally for water ingress and damage. Certified airtightness tapes and seals must be used in conjunction.

### 8.3.2 Ground Floor

Where the building sits on solid ground, an area of the ground floor is to be removed and inspected for its construction. If it is possible to remove the existing solid concrete floors, a radon barrier should be installed, followed by geotextile membranes, insulation and a new ground floor finish. Consideration should be given to installing an underfloor heating system during this process, which could be driven by a high-temperature air-to-water heat pump system.

The new ground floor is to be laid with limecrete and a lime mortar screed. Recycled foam glass or expanded clay aggregate can be used as loose-lay insulating layer beneath the limecrete, which will also inhibit ground water penetration. No cement is to be used for carbon mitigation purposes.

The suspended timber floor in the original house should be draughtproofed and insulated from above. This will require the careful removal of the existing timber floorboards, which should be numbered and set aside for possible reinstatement after insulation works have been completed. Care should be taken to not damage the skirting boards in the process.

Adequate ventilation must be maintained in the solum after the underfloor insulation and draughtproofing layers are installed. Existing underfloor vents should be cleared and additional vents may need to be installed.

### 8.3.3 Walls

All internal walls should be stripped of their wallpaper and internal insulation. It may be necessary to replaster some walls. If so, the existing plaster should be removed and damp walls should be left to dry out over the summer months before the new lime plaster is applied. The new lime plaster should be applied to the same depth as the existing. Drylining must not be used and an airtightness layer is not required with wet plaster.

While the plaster is off, the wall structure should be inspected for voids and repaired where necessary with lime mortar.

Given that an insulating lime render has been recommended for the exterior of the building, it is not recommended to insulate the internal face of the walls as well. The use of a regular lime plaster internally will allow moisture to be pushed out through the walls over the winter heating season, but the proposed external insulating render will retain more heat than the existing wall build up without trapping moisture.

#### *8.3.4 Windows*

Heat loss through windows happens in three forms: radiant (through the glazing), conductive (through the frames) and convective (draughts).

It is recommended that the historic windows be restored, draughtproofed and further insulated with low-profile removeable secondary glazing.

If the uPVC or metal-framed windows are to be replaced, they should be replaced with stylistically compatible timber-framed, slim double-glazed windows with draughtproofing to improve the airtightness of the building. Timber is less conductive than metal and is therefore more thermally efficient than uPVC. The design should be based on the existing original windows and the installation should reduce or eliminate draughts or water penetration.

Exterior vapour-permeable timber paints should be used to avoid trapping moisture in the timber frames, which will expediate rot.

Internal shutters should be repaired or reinstalled to significantly improve the retention of heat at night. The shutters should close tightly leaving no gaps for air leakage. Further thermal gains can be achieved with thick thermal curtains.

Window reveals should be insulated to avoid thermal bridging and moisture condensation. An insulating lime plaster is recommended as it also provides draughtproofing, but if the space is limited aerogel insulation may be used with an airtightness membrane and tape. Sheep's wool insulation may also be used to fill small gaps.

#### *8.3.5 Doors*

All retained doors and frames should be repaired, draughtproofed and the reveals should be insulated with an insulating plaster. Aerogel may be used with an airtightness tape if space is limited.

New doors should be assessed for full compliance with building and fire regulations and be historically appropriate for the building. The selection of doors with a low carbon footprint and low U-values should be the priority.

### 8.4 Additional Considerations

#### *8.4.1 Heritage Conservation*

No works should be undertaken that will harm or devalue the historic qualities and heritage value of the building and site. The intent should be to reverse previous inappropriate alterations while improving the energy and thermal performance of the building.

#### *8.4.2 Airtightness*

Airtightness is a relatively new consideration in heritage or traditional buildings, however it is extremely important to address in order to improve the energy efficiency of the building. It is estimated that 40% of heat loss in buildings is due to draughts.

Improving the airtightness of the building will lower operational heating requirements and carbon emissions. It is therefore one of the most cost-effective ways to improve energy efficiency.

Airtightness membranes and tapes for traditional buildings must also be moisture permeable. Special consideration should be given to the routing and re-routing of services to avoid unnecessary holes in the building fabric and airtightness layers.

### 8.4.3 Ventilation

Improved airtightness *must* correspond with an adequate ventilation strategy in order to maintain safe moisture levels and a healthy indoor environment. With increased insulation and airtightness, trickle vents will no longer ensure enough air movement. New vents will also need to be installed in the roof space in line with increased insulation and draughtproofing.

Strategically placed demand controlled extraction vents which are triggered by excess humidity may be an option for wet rooms (W.C., kitchens, laundry rooms, etc.), but ventilation requirements will be contingent on the number of people expected to use the building on any given day, indoor air pollutants and moisture levels. For larger buildings, a centralised heat recovery ventilation system may be more suitable to remove unsafe levels of toxins, $CO_2$ and humidity. It may be an option to route centralised ventilation ducting up through the existing chimney stacks.

Indoor Air Quality (IAQ) monitoring should be undertaken in a variety of occupied spaces to inform the requirements of a ventilation strategy, which will need to be very carefully worked out with a specialist in this area.

Ventilation units should be chosen that operate at less than 30db to avoid the impression that they are excessively noisy.

### 8.4.4 Energy Sources

To reduce the operational carbon emissions of the refurbished building, it is important to carefully specify the energy sources for heating, lighting, ventilation systems and other building functions. Inefficient fossil fuel-based energy systems (coal, oil, peat, gas) should be replaced with lower carbon alternatives. Although not carbon neutral, a high efficiency gas boiler would have lower emissions than an oil, peat or coal-based heating system. While electricity is still generated partially from fossil fuels in Ireland, a growing proportion of energy is generated from renewable sources so we can expect the electricity grid to continue to decarbonize over time.

The development of a new high temperature air-to-water heat pump now means they may be suitable for historic buildings. However, prior to their installation, the thermal efficiency of the building should be improved as much as possible to ensure the heat pump operates efficiently. Underfloor heating should be supplied by an air-to-water heat pump or ground-sourced heat pump properly sized for the building. Underfloor heating will provide low-level background heating, but infrared radiant heating panels should also be considered for top-up heating as they run off electricity and will thus become a more sustainable source of heat over time. Radiant heating provides occupants with a higher degree of comfort at lower temperatures by heating surfaces rather than the air, thus requiring less energy, providing a heat source that is not affected by ventilation and draughts and reduces the likelihood of damp and mould growth.

It can be difficult to integrate micro-renewables within the confines of a heritage building and/or site, however solar photovoltaic (PV) and thermal panels may be installed on a less noticeable roof of the building, on an outbuilding nearby or on the ground which has advantages for access and maintenance. Solar PV panels can be used to supplement the electricity use with a cheaper renewable source. A separate solar thermal system could also be considered for water heating. There have been advancements in creating solar PV panels to look like natural slate, which may be an option if a roof over the newer part of the building needs replacement. Given the extent of land with the property, consideration should be given to using some of the land for a PV farm to generate energy for Myross Wood House and perhaps the local community as well.

Lighting is to be carefully planned to suit the specific purpose of each space. All lighting should use low-energy LED bulbs, which use approximately 1/6$^{th}$ of the energy required by traditional incandescent bulbs. All new wiring needs to be well thought out and installed prior to final internal finishes.

All appliances should be energy efficient.

Detailed specification of energy systems will need to be made by a qualified professional within this industry.

### *8.4.5 Monitoring Efficiency & Performance*

In order to make this project an exemplar low carbon retrofit, we recommend that a monitoring programme be undertaken to assess the conditions and energy use before, during and after the refurbishment. A full suite of assessments for Myross Wood House may include in-situ u-value assessments on each type of wall build-up, petrographic analysis of structural stone and concrete, porosity tests on each façade, indoor air quality monitoring, thermal bridge analysis and hygrothermal analysis. Indoor air quality monitoring and interstitial moisture monitoring should continue after the retrofit works to ensure that a heathy environment is maintained for both the occupants and the building fabric. These tests will need to be undertaken by a specialist contractor and for a building of this size, will likely cost upwards of €25,000.

These tests will allow us to understand the performance of the existing building, to design low-risk retrofit measures and to document the success of our strategy with hard data over time. Best practice retrofit case studies are also in short supply in Ireland and there is an opportunity here to use Myross Wood House to build up local knowledge and to inform best practice guidance on the low-energy, low-carbon retrofit of historic and traditional buildings.

### *8.4.6 User Behaviour*

Building users should be made aware of how their behaviour impacts the energy consumption and internal environment of the building. Building users and occupants should be supplied with an easy-to-follow user manual that describes how to manage moisture and energy use in the most sustainable manner.

### *8.4.7 Life Cycle Assessment*

It is recommended that life cycle assessment be undertaken at concept design stage to assess the carbon impacts of the materials, systems and works recommended by the design team. Lower carbon options could be found at this stage for any materials, systems or works that have or will result in particularly or unnecessarily high embodied and operational carbon emissions.

### *8.4.8 Landscaping*

Landscaping around Myross Wood House can also contribute to its low carbon strategy. Any planting should be considered for its quality to the area, it's capacity for carbon sequestration and contribution to a cleaner environment.

If landscaping around the building is required or to be considered, soft scaping is recommended to manage the potential of extreme weather events or heavy rainfall.

Rainwater harvesting should also be considered for reuse on the site.

A landscape architect may be required to advise on the recommendations above.

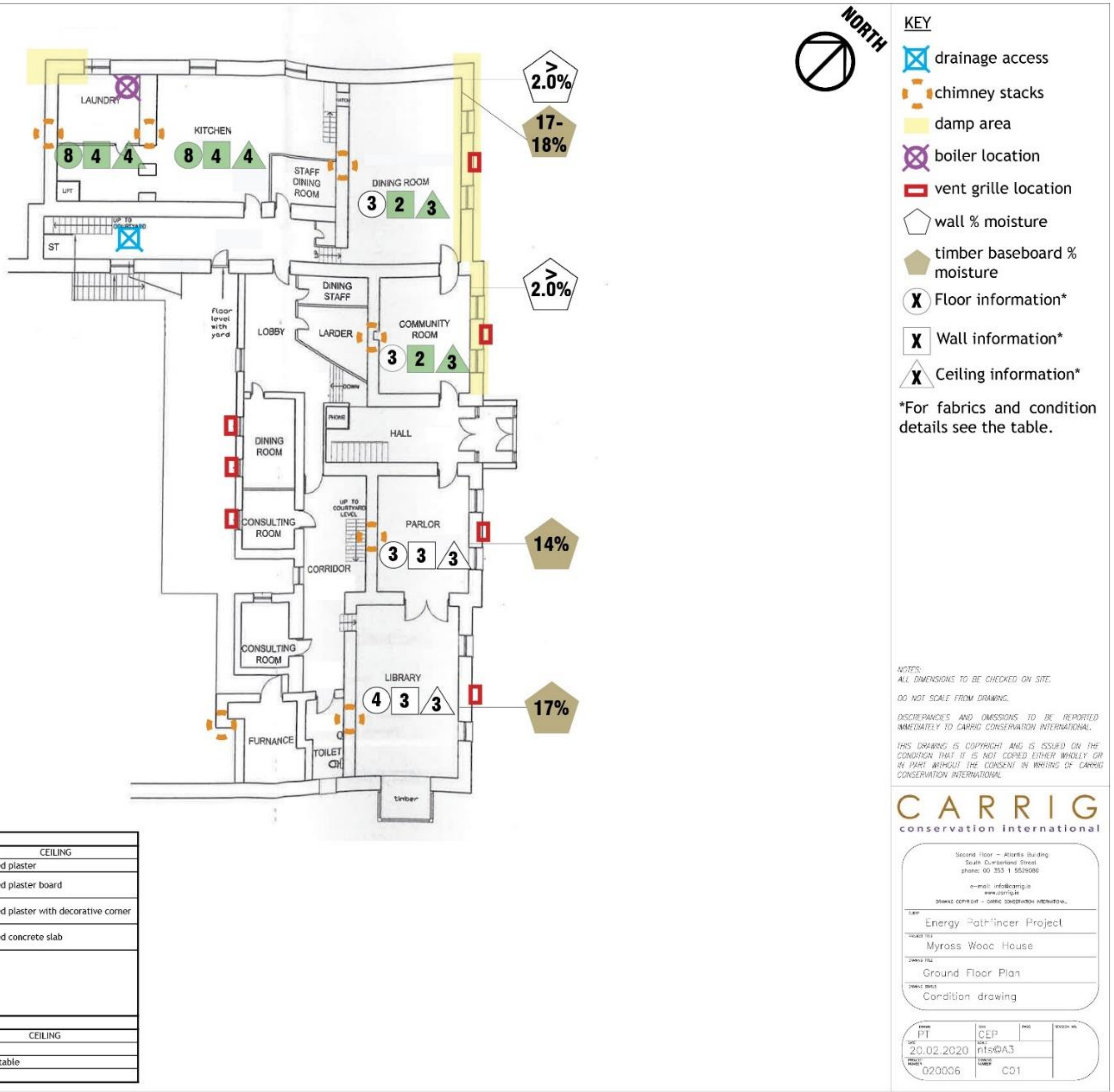
### *8.4.9 Site Management*

Depending on the future use of the building, consideration may need to be given to the development of a facility management file so that none of the low-energy or low-carbon interventions are interfered with or mistakenly changed in the short, medium or long term.

# 9 Appendix

## 9.1 Drawings

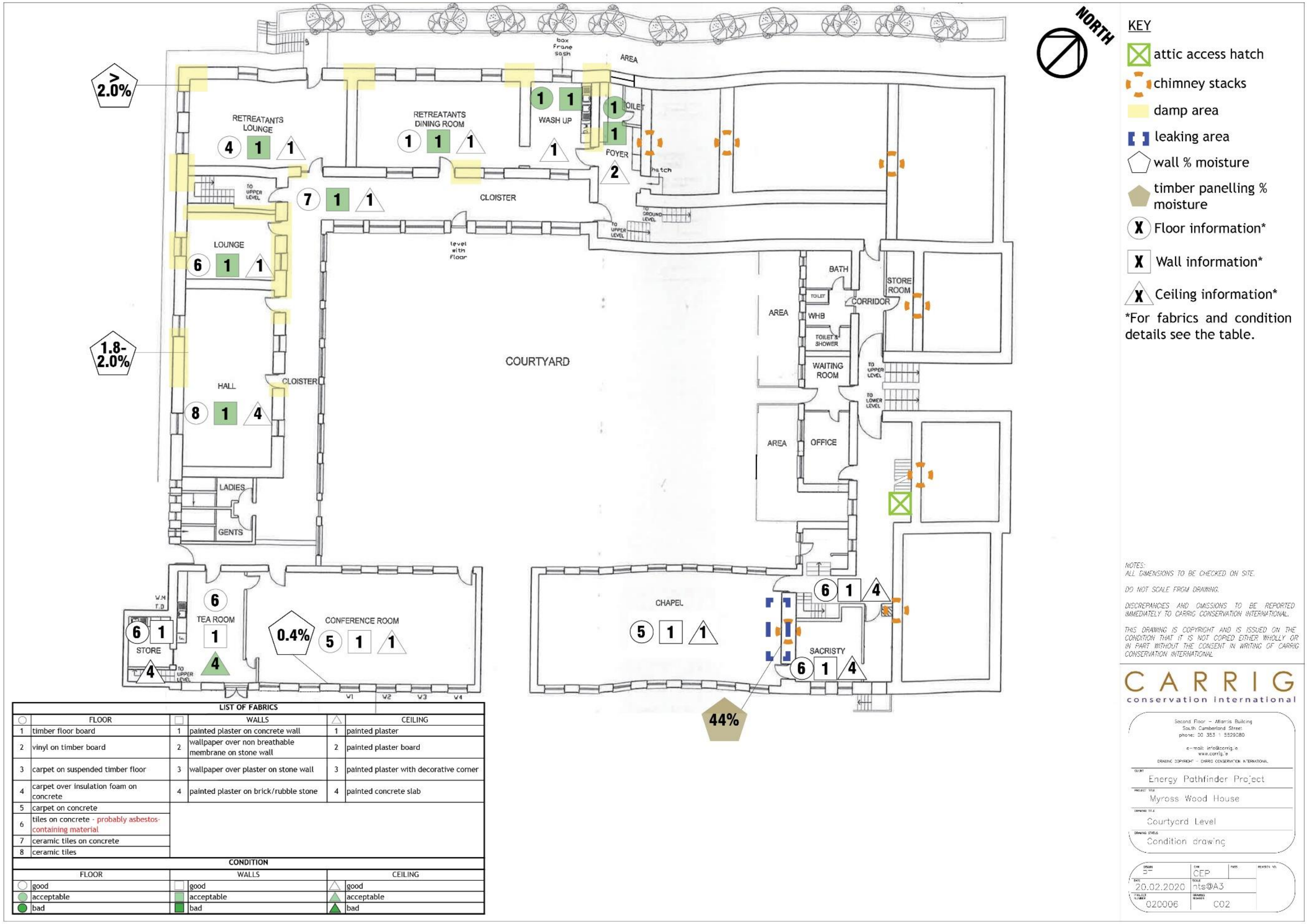
Please consult the drawings alongside the Condition Assessment (Section 6.1).




| LIST OF FABRICS | | | | | |
|---|---|---|---|---|---|
| ○ | FLOOR | □ | WALLS | △ | CEILING |
| 1 | timber floor board | 1 | painted plaster on concrete wall | 1 | painted plaster |
| 2 | vinyl on timber board | 2 | wallpaper over non breathable membrane on stone wall | 2 | painted plaster board |
| 3 | carpet on suspended timber floor | 3 | wallpaper over plaster on stone wall | 3 | painted plaster with decorative corner |
| 4 | carpet over insulation foam on concrete | 4 | painted plaster on brick/rubble stone | 4 | painted concrete slab |
| 5 | carpet on concrete | | | | |
| 6 | tiles on concrete - probably asbestos-containing material | | | | |
| 7 | ceramic tiles on concrete | | | | |
| 8 | ceramic tiles | | | | |

| CONDITION | | | | | |
|---|---|---|---|---|---|
| FLOOR | | WALLS | | CEILING | |
| ○ | good | □ | good | △ | good |
| ● (light green) | acceptable | ■ (light green) | acceptable | ▲ (light green) | acceptable |
| ● (green) | bad | ■ (green) | bad | ▲ (green) | bad |

*Figure 47. Ground floor plan - Myross Wood House.*




**LIST OF FABRICS**

| ○ | FLOOR | □ | WALLS | △ | CEILING |
|---|---|---|---|---|---|
| 1 | timber floor board | 1 | painted plaster on concrete wall | 1 | painted plaster |
| 2 | vinyl on timber board | 2 | wallpaper over non breathable membrane on stone wall | 2 | painted plaster board |
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| 5 | carpet on concrete | | | | |
| 6 | tiles on concrete - probably asbestos-containing material | | | | |
| 7 | ceramic tiles on concrete | | | | |
| 8 | ceramic tiles | | | | |

**CONDITION**

| FLOOR | | WALLS | | CEILING | |
|---|---|---|---|---|---|
| ○ | good | □ | good | △ | good |
| ● (light green) | acceptable | ■ (light green) | acceptable | ▲ (light green) | acceptable |
| ● (dark green) | bad | ■ (dark green) | bad | ▲ (dark green) | bad |

*Figure 48. Condition drawing, courtyard level – Myross Wood House.*


*Figure 49. Condition drawing, upper level – Myross Wood House.*

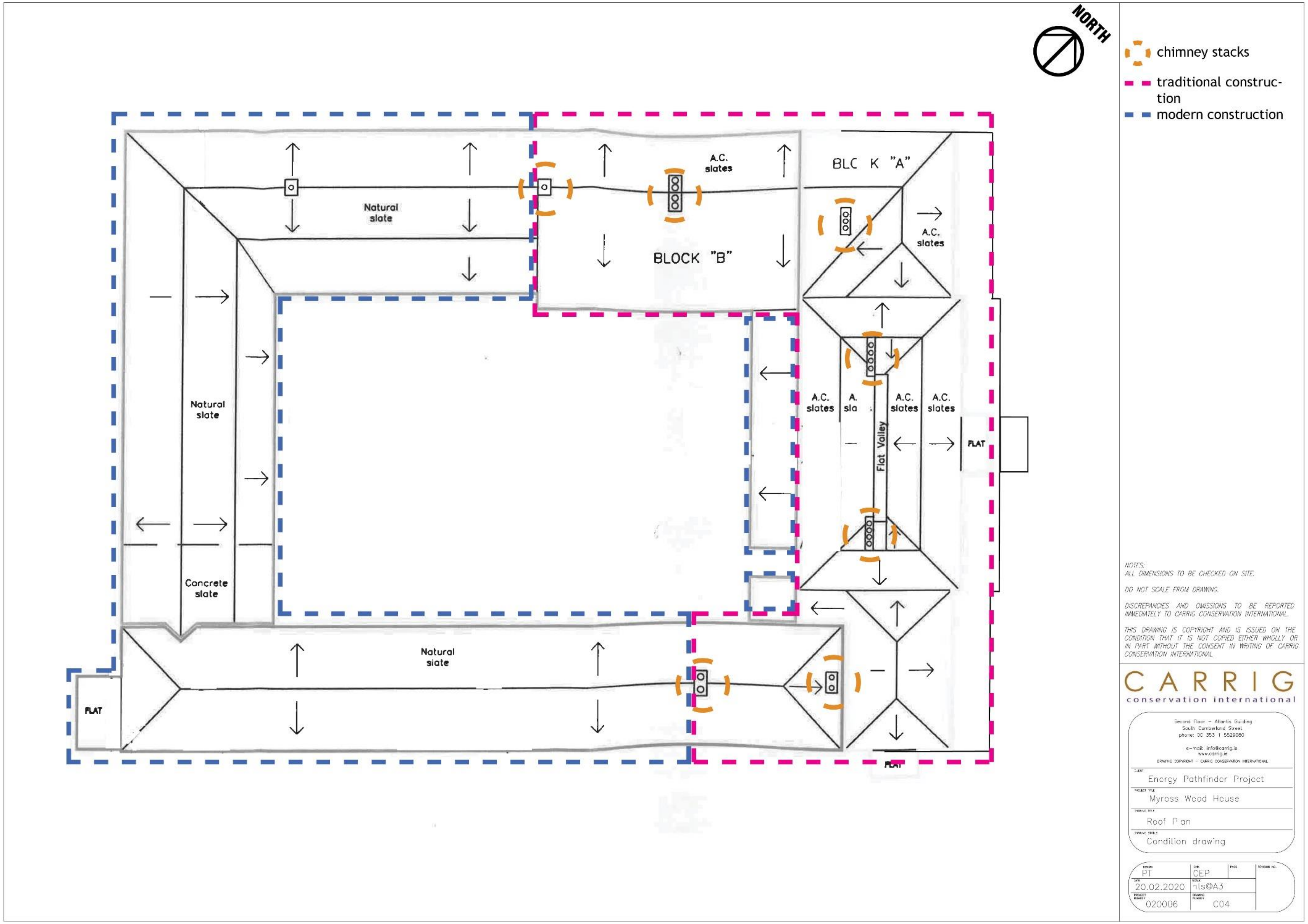


*Figure 50. Condition drawing, roof plan – Myross Wood House.*

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